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Economic and Political Factors in Infrastructure Investment: Evidence from Railroads and Roads in Africa 1960–2015

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Abstract

Transport investment has played an important role in the economic development of many countries. Starting from a low base, African countries have recently initiated several massive transportation infrastructure projects. However, surprisingly little is known about the current levels, past evolution, and correlates of transportation infrastructure in Africa. In this paper, we introduce a new data set on the evolution of the stocks of railroads (1862-2015) and multiple types of roads (1960-2015) for 43 sub-Saharan African countries. First, we compare our estimates with those from other available data sets, such as the World Development Indicators. Second, we document the aggregate evolution of transportation investments over the past century in Africa. We confirm that railroads were a "colonial" transportation technology, whereas paved roads were a "post-colonial" technology. We also highlight how investment patterns have followed economic patterns. Third, we report conditional correlations between 5-year infrastructure growth and several geographic, economic and political factors during the period 1960-2015. We find strong correlations between transportation investments and economic development as well as more political factors including pre-colonial centralization, ethnic fractionalization, European settlement, natural resource dependence, and democracy. This suggests that non-economic factors may have a significant role in the ability of countries to invest in these public goods.

JEL Codes: O11; O18; O20; H54; R11; R12; R40; N77

Keywords: Transportation Infrastructure; Public Investment; Railroads; Roads; Paved Roads; Africa; Growth; Institutions; Comparative Development; History

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Sub-Saharan Africa's transport infrastructure is limited compared to other developing regions. Road density is less than a third of South Asia's, and only a quarter of the network is paved (World Bank, 2010), against 60% in India (Government of India, 2016) and two-thirds in China (World Bank, 2015a). According to our data, there are only 3,700 km of highways in Sub-Saharan Africa vs. 24,000 km in India (Government of India, 2016) and 111,900 km in China (Government of China, 2016). Approximately 55,000 km of rail serve the continent, but nearly all of it outside South Africa dates from before 1970, with limited rehabilitation. Roughly 16 billion passenger-kilometers per year are traveled by rail (of which 11 is South African commuters), compared to nearly 800 billion in both China and India (World Bank, 2016b). While limited income, tax revenue, and financing capacity surely contribute to low investment and low stock, there is still a great deal of variation, both across countries and across time periods.

The past decade has seen a substantial increase in investment, with many African countries initiating high profile transportation infrastructure projects rehabilitating existing roads and rail and building new ones (The Economist, 2015). They have been enabled in this by more stable growth after 2000, and relatively low debt levels.[1] External financing from private partnerships, traditional ODI, and China have also played an important role, each tripling between 2004 and 2012 (Gutman et al., 2015).[2]

Government and funding agencies expect transformative results. The often-announced goals include connecting remote areas, stimulating regional integration and in some cases easing commutes and facilitating overseas trade.[3]

It is thus a good time to take stock of past investments and what drove them. Surprisingly little is known about the history of transportation infrastructure in Africa, even though it represents a substantial investment. Transport accounted for 14% of

[1]Since 2000 annual per capita GDP growth has averaged over 2%, following 25 years with an average near -1%. Debt service as a fraction of GNI, over 4% in the 1990s, is now below 2% (World Bank, 2016b).

[2]Several countries have initiated various widely reported giant transportation projects such as the Abidjan-Lagos motorway ($8 billion), the Mombasa-Kampala-Kigali railway ($14 billion), the Tanzania-Gabon railway ($33 billion) and the Trans-Kalahari railway ($9 billion).

[3]For example, the African Development Bank press release announcing funding for the Dakar-Diamniadio highway in Senegal refers to a "gateway to a new economic development pole [...] it is expected to improve the living environment of people living in the vicinity of the road as well as enhance the overall operation of the transportation system, accelerate growth and promote regional integration [...] its impact goes beyond Senegal to the Economic Community of West African States (ECOWAS)" https://www.afdb.org/en/news-and-events/article/afdb-approves-fcfa-32-billion-loan-for-dakar-diamniadio-highway-4895/.

World Bank lending, and 22% of African Development Bank disbursements 2012-2015 (World Bank, 2016a; African Development Bank, 2012–2015). There are many country-level studies that focus on selected periods and projects, but very little evidence on the big picture. The lack of comprehensive data are an important reason for this limitation.

This paper aims to fill this gap. First, it presents new, comparable data for 43 sub-Saharan African countries on the evolution of road stocks over 50 years (1960–2015), and rail stocks over 150 years (1862–2015), and compares them with more limited existing sources, such as the *World Development Indicators* database (World Bank, 2015a). Second, it combines them with existing sources to describe an overall picture of the evolution of Sub-Saharan African transport infrastructure over the past century. Third, using long-difference regressions, it reports correlates of infrastructure development (railroads, highways, paved roads and improved roads) for the period 1960–2015, showing which kinds of countries, in terms of their income, level and distribution of population, geography, history, sources of income, and governance, build more railroads and roads, overall, and near and far from core areas.

The paper contributes to the macroeconomic literature on the relationship between transportation infrastructure and economic development. Many studies consider the effects of transport infrastructure. Using mostly cross-country regressions, they show an important role of transport infrastructure and market access on exports and/or growth (Amjadi and Yeats, 1995; Easterly and Levine, 1997; Radelet and Sachs, 1998; Canning, 1999; Canning and Bennathan, 2000; Limão and Venables, 2001; Canning and Pedroni, 2008; Um et al., 2009; Buys et al., 2010; Calderón and Servén, 2010, 2014).[4]

However, few papers formally consider the correlation between transportation infrastructure development and various potential determinants as we do. Most of the studies cited above take transportation infrastructure as given, or use an identification strategy that helps estimate a causal effect of transportation infrastructure. Yet, if such investments do indeed have strong effects on trade and economic growth, knowing why some countries are able and willing to realize such investments, and why other countries are not, can give us a richer understanding of long-run growth. In examining

[4]There is also a recent literature on the local and general equilibrium effects of transportation investments, and trade costs more generally, in Africa (Atkin and Donaldson, 2015; Jedwab and Moradi, 2016; Storeygard, 2016; Berg et al., 2016; Jedwab et al., 2017; Jedwab and Storeygard, 2017), and a larger one elsewhere (Faber, 2014; Bird and Straub, 2014; Ghani et al., 2016; Asher and Novosad, 2016; Donaldson, forthcoming). See Berg et al. (2017) for a survey of the literature on developing countries.

the correlates of rail and road expansion, we address this question.

The closest work to ours is Canning (1998), to our knowledge the only study that has attempted to recreate a consistent series of transportation infrastructure provision levels at the country level since the mid-20th century and investigate its correlates. Canning (1998) and Canning and Farahani (2007) provide an annual database of physical infrastructure stocks for a cross-section of 152 countries for 1950-2005. It contains three measures comparable to ours: length of roads, paved roads, and railway lines. Like Canning (1998), we consider these infrastructure stocks' relationship with income, population, urbanization, and area and find that: (i) there is convergence in transportation infrastructure, as the countries with more infrastructure build less infrastructure *ceteris paribus*; and (ii) faster growing countries build more roads. Overall, transportation investments appear to be procyclical in our context, in line with the literature on the procyclicality of government expenditure in Africa (Thornton, 2008; Lled et al., 2011). Also, like Canning (1998), we find that larger and more populated countries build more transportation infrastructure, probably to better connect their different regions and people. However, unlike the global sample of Canning (1998), we find a positive relationship with urbanization in Africa. This is consistent with, for example, an increased importance of trade in more urbanized countries.

We then go beyond the analysis of Canning (1998) in several dimensions, focusing on paved roads investments, the main transportation investments of the post-colonial period. First, we consider several additional potential determinants related to geography, historical and present-day institutions, and economic structure, conditional on the core variables described above (income, population, urbanization, area). Second, we study how all of these variables relate separately to paved road investments in central and peripheral regions within countries, and thus to spatial inequality.

The seminal book by Herbst (2000) also considered what drives infrastructure investment in Africa. He hypothesized that political factors such as ethnic diversity, the identity of the colonizer, the weakness of the state, conflict, the political regime and the level of corruption were also significant drivers of the construction of roads in Africa in both the colonial and post-colonial periods. We test these hypotheses in a formal econometric framework. We find that political factors were and are still major determinants of infrastructure building in African countries. More precisely, our results suggest that transportation investments are positively correlated with pre-colonial centralization, European settlement, and democracy, and negatively correlated with ethnic fractionalization and natural resource dependence.

A directly related paper is Gennaioli and Rainer (2007) who show that strong (centralized) pre-colonial political institutions allowed colonial and post-colonial African governments to more efficiently provide public goods such as roads. However, this paper uses cross-sectional data to measure a level effect circa 1986, whereas we use panel data and measure a growth effect for the period 1960-2015. More generally, there is a large literature on the long-term effects of historical political centralization and European settlement on state capacity and institutional quality, and by extension the provision of public goods (Herbst, 2000; Acemoglu et al., 2001; Bockstette et al., 2002; Nunn, 2008; Acemoglu and Robinson, 2010; Fenske, 2013; Michalopoulos and Papaioannou, 2013, 2015). Another literature investigates the effects of democracy, and institutions more generally, on public good provision and/or development (Barro, 1996; Persson and Tabellini, 2006; Papaioannou and Siourounis, 2008; Michalopoulos and Papaioannou, 2014; Acemoglu et al., forthcoming).

Many of the other potential determinants we consider have been studied extensively in literatures relating them to broader development outcomes. There are several papers on the role of ethnic fractionalization and ethnic inequality on the provision of public goods and economic development more generally (Easterly and Levine, 1997; Alesina et al., 1999, 2003, 2014; Miguel and Gugerty, 2005; Habyarimana et al., 2007; Putterman and Weil, 2010; Fenske and Zurimendi, 2015; Michalopoulos and Papaioannou, 2016; Alesina et al., 2016; Depetris-Chauvin and Durante, 2017). These papers show that countries and regions with higher levels of ethnic diversity underinvest in public goods, with potentially negative consequences for growth. However, only Easterly and Levine (1997) and Alesina et al. (1999) report correlations with road-related indicators, the former just a bivariate correlation, and the latter across American cities. A large literature on the political resource curse demonstrates that natural resource dependence can lead to corruption, with government budgets being used for private transfers to politicians rather than for funding public goods (Robinson et al., 2006; Mehlum et al., 2006; Vicente, 2010; Buonanno et al., 2015). However, these studies do not investigate how resource rents affect transportation investments.[5]

Finally, we study the correlations between infrastructure investments and many different potential determinants, but we cannot identify causal effects of each one of them. In that sense, our paper is in the spirit of the growth literature whose goal was to benchmark the different determinants of growth (see for example Sala-i-Martin, 1997).

The rest of paper is organized as follows. Sections 1 and 2 present the data and the background. Section 3 discusses the methodology and the results. Section 4 concludes.

1. Data

We focus on the 43 countries of mainland sub-Saharan Africa and Madagascar, for which we have country-level data on railroads (1862-2015), different types of roads (1935-2015), and various measures of economic and political development.[6]

1.1. Stocks of Roads and Railroads

Roads. Our chief data innovation is to provide spatially explicit and comprehensive information on *paved* and *improved* (gravel or laterite) roads and *highways* (which we refer to collectively as non-dirt roads) for several years between 1960 and the present. As described in greater detail in Jedwab and Storeygard (2017), the spatial location of the roads is from Nelson and Deichmann (2004), nominally representing the situation as of 2004 based primarily on the US government's *Digital Chart of the World* database. The nature of the road surface is from 64 Michelin road maps produced on average every three years between 1961 and 2014 for three broad regions: Central/South (20 countries; 1961–2012), North/West (18; 1965–2014) and North/East (5; 1966–2012). Figure 1a show the road network in the 43 countries circa 2015. These data are available for 925 country-years. We linearly interpolate and extrapolate to obtain a balanced panel of 43 countries over 56 years (1960-2015), a total of 2,408 country-years.

Michelin draws its information from four sources: (i) the previous Michelin map, (ii) new government road maps, (iii) direct information from its tire distributors across

[5]On a micro scale, Collier et al. (2015) consider the determinants of the unit cost of road construction, using a sample of 3,322 projects 1984–2008 in 99 low and middle-income countries. They find that construction costs are higher in conflict countries and countries with higher levels of corruption. Our work complements theirs by focusing on built quantities rather than building costs.

[6]This excludes North Africa, and the five following small island African nations: Cape Verde, Comoros, Mauritius, São Tomé and Seychelles. We do not separate Sudan and South Sudan.

Africa, and (iv) correspondence from road users including truckers. As Michelin has been one of the largest tire companies in the world for many years, its network of distributors and customers is large, and their information represents a potentially large improvement to government maps, which are not regularly updated. Still, these data are unlikely to report all improvements immediately, and they are perhaps less likely to report substantial degradation in surface quality than substantial improvements. Finally, we cannot capture the quality of roads within a surface class, so when a severely potholed paved road is resurfaced, our data do not reflect this.

We supplement our data with three other sources. First, Herbst (2000, Tables 3.1 and 5.3) reports estimates of total road density (km per sq km of land) for 1935, 1950, 1963 and 1997 for 33, 27, 38 and 38 sub-Saharan African countries, respectively.[7] In his analysis, roads are defined as (p.85): "anything that could reasonably be said to be able to carry motor traffic at least part of the year (i.e., the dry season)." Second, Canning (1998) reports total and paved road length (km) for 40 sub-Saharan African countries 1950–1995, and Canning and Farahani (2007) provides paved roads data through 2002, using data from World Bank (2006) and harmonizing it with the Canning (1998) data. Third, the *World Development Indicators* (WDI) data set (World Bank, 2015a) reports total roads and paved fraction for selected country-years 1990–2015, using data from the International Road Federation's *World Road Statistics* and electronic files.

Canning (1998) relies on the International Road Federation's *World Road Statistics*, but also the *Statistical Yearbooks* of the UN and national sources. He notes that "The international data on total roads are patchy, with frequent gaps and many large changes that are often quickly reversed. Different countries define roads differently, and the definition of a road often changes within countries over time." (p. 534). Canning's assessment of paved roads is more positive, suggesting that processing solves most inconsistency problems, and that the remaining errors are due to countries not reporting urban roads in some years. As our data exclude urban roads, consistent with Michelin's purpose of guiding long distance travel, they are not subject to this problem.

Railroads. Figure 1b shows the rail network in the 43 countries circa 2015 from Jedwab and Moradi (2016), who assign construction dates from various sources to modern rail

[7] For the years 1935 and 1950, the road density of Burundi and Rwanda was proxied by the road density of "Ruanda-Urundi", and the road density of 14 former French colonies was proxied by the road densities of "French Equatorial Africa" and "French West Africa".

locations from the *Digital Chart of the World* (DCW). Figure 2, shows the evolution of the stock of railroads in the 43 countries annually since 1862. No information is available on railroads taken out of commission. Canning and Farahani (2007) and World Bank (2015a) report rail figures for selected countries 1950–2004 and 1980–2012.[8]

1.2. Other Data

Per capita GDP. Data on per capita GDP (expressed in 1990 International Geary-Khamis $) 1950–2010 comes from Bolt and van Zanden (2014), based on Maddison (2008).[9] Values for 2011–2015 (and a few countries 2009–2010) are constructed using 2010 (2008) values and per capita PPP GDP growth rates from World Bank (2016b).

Population, urbanization and area. Annual population data 1950 to 2015 are from United Nations (2015a). Pre-1950 data are from Manning (2015). United Nations (2015b) provides quinquennial urbanization and primacy (the share of the largest city in the urban population) rates 1950 to 2015. The urbanization rate circa 1910 comes from Jedwab and Moradi (2016). It is defined as the share of towns with a population above 10,000 inhabitants in the total population. Surface area (including water bodies) and land area (excluding water bodies) in sq km come from World Bank (2015a).

Physical geography. From Nunn and Puga (2012), we obtain the distance from a country's centroid to the nearest coast, the terrain ruggedness index, and percentage shares of a country's land area that is within 100 km from a coast, in a tropical climate, in a desert, and containing fertile soil. Average precipitation 1962–2014 is from World Bank (2015a). We also create a dummy for landlocked status.

Pre-colonial institutions. From Bockstette et al. (2002), we obtain for each country the state antiquity index, the discounted sum of three indicators of governance every 50 years from 1 to 1950 (using a discount factor of 5%). The indicators are whether there was a government above the tribal level, whether the government was foreign or locally based, and how much of the modern territory was ruled by this government. This variable is missing for 6 countries. From Gennaioli and Rainer (2007), we obtain the degree of precolonial political centralization: the share of the non-European population

[8]Canning and Farahani (2007) draws from Mitchell (1995) and the World Bank *Rail Statistics Database*.

[9]The 1990 International Geary-Khamis $ is a hypothetical unit of currency that has the same purchasing power parity that the U.S. dollar had in the United States in 1990. Using 1990 as a benchmark year is standard among economic historians using historical data on per capita GDP.

from ethnic groups with centralized political institutions before colonization. The number of slaves exported between 1400 and 1900 is from Nunn and Puga (2012). Indices of ethnic and linguistic fragmentation are from Alesina et al. (2003).

Colonial institutions. From Acemoglu et al. (2001), we obtain the settler mortality rate during the early colonial period, which we use as a proxy for the type of colonial strategy – "extractive" or "settlement". Data are missing for 19 countries. The percentage of the year 2000 population descending from people who resided in Europe in 1500 is from Putterman and Weil (2010). From La Porta et al. (2008), we create a dummy equal to one if the country's legal origin is French, and zero if it is English. We also know the main colonizer of each country, and when a country became independent.

Post-Colonial institutions and economic structure. From Center for Systemic Peace (2015b), we obtain for each country and year the combined polity score, an index from -10 to 10, with values below -5 representing autocracies, -5 to 5 mixed regimes, and above 5 fully institutionalized democracies. We consider two binary variables based on this scheme: non-autocratic (score over -5), and democratic (score over 5). From World Bank (2015b), we obtain for each country the rule of law, government effectiveness, regulatory quality and control of corruption indexes. We use country averages for the period 1996–2014, since no earlier values are available. Using data from Center for Systemic Peace (2015a), we create for each country-year a dummy equal to one if there has been a major international or intranational conflict in the country in the past five years. Lastly, from Gollin et al. (2016), for each country every 5 years from 1960 to 2015, we know the shares of mining exports (including fuels) and agricultural exports in merchandise exports, as well as the share of merchandise exports in GDP.

2. Aggregate Patterns in Railroad and Road Building

2.1. Railroads 1862-2015

Figure 2 shows the evolution of the African rail network. The first railroad in sub-Saharan Africa was the Cape Town-Wellington Railway in 1862 in South Africa. African railroads were limited to South Africa until the 1890s, when a rapid expansion began following the 1885 Berlin conference and the scramble for Africa. By 1904, the median country in our sample had a railroad. The mean year of first rail construction is 1909.

Colonial powers built railroads initially to ensure military domination, but also to boost trade (Chaléard et al., 2006; Jedwab and Moradi, 2016; Jedwab et al., 2017). "By the beginning of this century railways had taken over from river transport as the chief means of linking the interior of tropical Africa with the coast, and therefore with the rest of the world." (O'Connor, 1971, p.135). Rail reduced freight costs dramatically. Circa 1914 in Ghana, railroads were roughly 10 times cheaper than headloading. They were a factor of 2 to 5 times cheaper than trucks, canoes, and steamboats (Jedwab and Moradi, 2016). In northern Nigeria in 1926, rail transport was 15 times cheaper than headloading and 6 times cheaper than trucks (Chaves et al., 2014), while in Kenya in 1902, it was 100 times cheaper than headloading (Jedwab et al., 2017). In South Africa in 1905, rail transport was 3 times cheaper than ox-wagon transport on road (Fourie et al., 2015).

The age of rapid expansion came to an end in the mid-1930s with European governments limiting their colonial investments due to the Great Depression and World War II (Jedwab and Moradi, 2016). Another expansion began in the mid-1950s at the end of the colonial period. Even in the late 1960s, some commentators were still optimistic about the future of railways in Africa. "Rail traffic is still increasing in most of tropical African countries, and technical improvements are still being made on many lines. Certain new railways are under construction, and many more are planned." (O'Connor, 1971, p.142). However, this period of expansion ended in the the mid-1970s, when, as shown in Figure 3, a further two decades of economic stagnation and decline began. Economic recovery since 1995 has seen rehabilitation of some lines (such as the Addis Ababa-Djibouti Railway, completed in 2016). In the interim period, traffic collapsed in most countries, in the face of deteriorating service and increased competition from roads (Gwilliam, 2011; Jedwab and Moradi, 2016; Jedwab et al., 2017). Figure 4 shows that 74% of today's 66,000 km railroad network was built by 1929, 88% by 1960, and 96% by 1975. Nearly 50% of today's network was built between 1896 and 1916. The early stages of this trajectory are broadly similar to the early United States rail network, though somewhat more lagged and geographically concentrated. The US rail network, begun in 1830, reached 10 percent of its peak (c. 1915) length in the late 1850s, and nearly 50% of the peak length was built between 1870 and 1890 (Rodrigue, 2017).

Railroads were a colonial transportation technology in Africa, and have barely survived the economic crises of the 1980s and 1990s, in contrast to China and India, where they are still widely used today (African Development Bank, 2015).

We (JS) report a balanced panel of railroad length (km) for each of the 43 countries from 1862 to 2015. Canning and Farahani (2007) reports values for 1,447 country-years, 61% of possible values in the period covered, 1950–2004. Among these, our values are within 25% of Canning's value 84% of the time. Net of country and year fixed effects, the correlation between raw values of Canning's and JS is 0.44. One difference between the two datasets is that by construction, JS is non-decreasing in each country. Canning's data shows some decreases, some of which are likely real, but others of which, especially when counteracted within a few years, are possibly spurious. WDI reports rail length for the period 1980–2012, when there was minimal change over time, and only for 33% of possible country-years during that period. Since this is a period of minimal rail expansion, we do not further investigate the WDI rail data.

2.2. Roads 1897-2015

Roads capable of supporting vehicular traffic were also a product of colonization. As explained by Herbst (2000), there were already "roads" in the centralized political entities of pre-colonial Africa. For example, he writes that (p.41): "The Ashanti empire [in Ghana] was able to extend control over relatively large distances and have some of the attributes of a modern nation-state because of an extensive series of roads that converged on the capital, Kumasi." However, these roads were not designed for motor vehicles, and there was no such vehicle in Africa before the late 19th century. The first recorded car ride in South Africa was in 1897 (Wilburn, 1982). According to Perkins (2003, p.41), "the first motor journey from Cape Town to Johannesburg took place in 1905 over a period of 11 days on roads which were dusty, full of potholes and frequently obstructed by farm gates." The first car to be imported to Ghana was in 1902, and by 1913 there were only 12 cars in Ghana (Heap, 1990). The first car to be imported in Nigeria was in 1906 (Ekundare, 1973). Kenya's first road was begun in 1890, but "fell into disuse after the railway was completed" in 1902 (Soja, 1968; Ogonda, 1992).

Over the next few decades, the colonizers invested in motor roads mostly as a way to reach places unconnected by railroads, in order to further extend their control over their territory (Herbst, 2000). In Ghana, British colonial rule brought more consistent maintenance of narrow footpaths, and by 1900, several roads were built, both for military purposes, to gold mines, to palm oil production zones, and to bypass rapids on the Volta River (Pedersen, 2001). As Wrigley (1986, p.83-84) notes: "road building was the second great thrust of the colonial transport revolution. Some roads were in fact carved through the bush even before there were any railways, because of the illusory hope of using ox-drawn wagons or simply to make easier the passage of porters, donkeys and bicycles, which in Africa carried commodities as well as people. But the main stimulus was of course the advent of the motor-lorry. A few motor-vehicles made their appearance in the decade before 1914, but the main influx was in the 1920s." However, until the 1930s, railroads were still a cheaper form of transport than roads, and most African countries had focused their construction efforts on connecting a few cities and establishing feeder roads for the railroad, for example in Ghana (Pedersen, 2001), Kenya (Soja, 1968), Nigeria (Ekundare, 1973) and South Africa (Perkins, 2003). Herbst (2000, p.85) writes that road densities circa 1935 suggest "how unimpressive the colonial extension of power was throughout Africa in the 20th century." It is only after World War II that African countries started significantly developing their road network.

Figure 5 shows the evolution of total road density (km per sq km of land) as a population-weighted average across all available countries in any given year, for selected years from 1935 to 2011, based on Herbst (2000) (1935, 1950, 1963 and 1997), Canning (1998) (1950–1995) and WDI (1990–2011). Coverage of large countries is relatively good through 2000. The Herbst (2000) sample reports for between 27 and 38 countries per year in each of its four years, an average of 34 per year. Canning (1998) averages 23 countries in its 46 years. WDI averages 23 countries in its 22 years.

More precisely, to reconstruct the series shown for Canning and WDI, we interpolate and extrapolate their country-level data to fill the missing gaps in each period (1950–1995 for Canning and 1990–2011 for WDI) and divide by land area. We then obtain the population-weighted average of road density for the full sample in each year. Coverage of small countries is much less consistent in both datasets, but they cannot affect the population-weighted average greatly. Lastly, as Canning (1998) notes, in addition to country coverage varying greatly from year to year, within-country coverage also varies from year to year, as definitions change. For both of these reasons, Figure 5 reports a five-year moving average of both Canning (1998) and WDI.

All three series report a broadly consistent picture of steady growth in total road density over time. The Canning data show steady investment in the late colonial period of the 1950s, then stopping at independence, much earlier than rail and paved road investment, which lasted until the mid-1970s and mid-1980s, respectively. Consistent with this, O'Connor (1971, p.142-143) reports "In most tropical African countries road traffic increased extremely rapidly during the 1950s, and in many of them roads first challenged railways as the chief means of transport during this period. Traffic has continued to grow everywhere in the 1960s, though generally at a rather slower rate". The WDI data suggest much more rapid increases, much more so than paved roads, starting in the improving economic climate of the 1990s. Today, roads are by far the main means of transportation (Gwilliam, 2011; Jedwab and Moradi, 2016). For example, Herbst (2000, p.161-162) writes: "Roads are as vital as ever to the workings of African states: approximately 80 to 90 percent of Africa's passenger and freight traffic travel by road and road transport provides the only form of access to most rural communities".

In Figure 4, we show how much today's total road network was likely to be already built in year t. We assume it was 0 before 1898, and linearly interpolate to Herbst's first value in 1935, and from there to the Canning and WDI values for 1950-1990 and, 1990-2011 respectively. Note that we use the moving average of this reconstructed series (+/- 2 years), to avoid some sharp changes in Canning and WDI that we assume are due to reclassification. By 1935, about 15% of today's road network already existed, and by 1960, this figure was almost 50%. The subsequent quarter century saw much slower growth, while the past 30 years shows more rapid growth. Note however that the past 30 years data are primarily from the less reliable WDI dataset.

2.3. Improved and Paved Roads and Highways

Paved roads were essentially a postwar phenomenon in sub-Saharan Africa. "Except in the far south, there were hardly any tarred roads outside the towns until after the Second World War" (Wrigley, 1986, p.84). Even in South Africa, there were only about 2,000 km of paved roads in 1940 (Perkins, 2003; Perkins et al., 2005).

Figure 6a reports the evolution of the paved, improved and highway networks in JS. According to Michelin, the first restricted access highways did not appear in Africa until 1972, and by 2012 they were limited to 3,400 km, 87% of which is in Nigeria and South Africa. Paved roads triple between 1961 and 1984, before leveling off in the mid-1980s. The stock of improved roads varies little throughout the period.[10]

Figure 4 extrapolates these figures backwards using the year of 25 countries' first paved road, based on the Michelin maps and various sources.[11] The earliest paved road was in Ghana in 1924, followed by Nigeria in 1930, Zimbabwe in 1933, South Africa in 1938 and Kenya in 1945. Among the 25 countries with information we could find, the mean and median year of first paved road are 1955 and 1960 respectively. We thus assume that for countries with no information, the first km of paved road was built in 1960. Given that we have subsequent paving information from Michelin, this can only bias the pre-1960 estimates downward. We estimate that today's paved network is 185,000 km, a more than four-fold increase over the 42,000 km present in 1960.

Our paved roads data are available for 925 out of a total possible 2,408 country-years between 1960 and 2015. No country is missing in our analysis, and for all countries we have between 20 and 23 years of data (mean gap = 2; median = 2; min = 1; max = 7).

[10] The precise set of improved roads today is not the same as it was in the 1960s. Many early improved roads were trunk roads that were later paved, while other, previously dirt, roads were improved.

[11] The main sources are: Communaute Economique Europeenne (1966), O'Connor (1971, 1978), Ekundare (1973), Mlambo (1994), Harrison (1995), Dierks (2001), Perkins (2003), Perkins et al. (2005), Gewald et al. (2009), Jedwab (2013), Burgess et al. (2015) and Jedwab and Moradi (2016).

Canning and Farahani (2007) has data on paved roads for 1,319 out of a possible 1,849 country-years between 1960 and 2002, missing only one country completely. For the 609 observations that we have in common, net of country and year fixed effects, the correlation between Canning and Farahani (2007) and JS is 0.70. The Canning (1998) data are even more highly correlated with the JS data, at 0.96 over 538 observations ending in 1995. The World Bank (2015a) data base contains values for 40% of 946 potential observations during the period for which it is available, 1990–2011. While data for at least one year are available for 42 countries, six of these, including the DRC and Nigeria, two of the most populous African countries, have data for only one year. Among the 151 country-years with data for JS and World Bank (2015a), the correlation net of country and year fixed effects is 0.10. This lower correlation is likely due to the fact that the overlapping period is one with little change, at least according to the JS data.

Figure 6b compares the evolution of the interpolated Canning and Farahani (2007) and JS series over their common period where neither requires extrapolation (1965–1999), indexed to 1965 due to the levels difference. It also includes a variant of the Canning and Farahani (2007) dataset ("Canning (raw)") that excludes data from World Bank (2006). Including World Bank data makes the Canning and Farahani (2007) data diverge further from JS, even in the early 1990s before the Canning and Farahani (2007) series is primarily extrapolated. World Bank (2015a) is also included, indexed to Canning and Farahani (2007) in 1999. Not surprisingly, it is close to Canning and Farahani (2007) after 1995 when Canning and Farahani (2007) is largely based on it.

Figures 7a and 7b report the evolution of the share of paved roads (incl. highways), as well as paved and improved roads, according to JS, in the total network, based on two different denominators. Figure 7a relies on a static value circa 2004 from Nelson and Deichmann (2004). It implies that the highway/paved share has risen steadily from 4% to 16%. Figure 7b normalizes by (interpolated) total road estimates from Herbst, Canning and Farahani (2007) and World Bank (2015a). Since these data imply a steady increase in the stock of total roads, the slowdown in road paving after 1984 implies a decrease in the highway/paved road share, from a peak of 7% to under 5%. The lower values suggest that these stock estimates include more roads than the spatially explicit Nelson and Deichmann (2004) data. We believe that the true evolution of the total road stock lies somewhere in between the two. In both cases, paved road investments stalled by the mid-1980s, probably due to the economic crisis (see Figure 3).

2.4. Total Road Network Value

The final aggregate time series we construct is of the total value of the stock of road infrastructure, as embodied in construction costs. According to data for projects in 99 low- and middle-income countries, inside and outside Africa, between 1984–2008 from Collier et al. (2015, Table S.2), building a paved road ("upgrading") is about 3 times more expensive than building an improved road ("new 1-lane road"), while building a new 4-lane highway and a 2-lane highway are about 9 and 3 times more expensive than building a paved road respectively. Repaving a road ("asphalt mix resurfacing") is about 4 and 15 times more expensive than re-improving ("gravel resurfacing") and re-tracking ("unsealed preventive treatment"). Likewise, according to project data for 13 Sub-Saharan African countries in the 2000s from Alexeeva et al. (2008, Table 3.3), paving ("upgraded to paved") a road is about 5 times more expensive on average than improving ("gravel") a road. Similarly, Burgess et al. (2015) using data from various reports from the colony of Kenya in the 1950s find that building paved roads ("bitumen road") is about 3 times more expensive than building improved roads ("murram road") and 12 times more expensive than building tracks ("low-cost road").

We thus assume that a highway is 9 times more expensive than a paved road, a paved road is 4 times more expensive than an improved road, and an improved road is 15 times more expensive than a dirt road. Using (9*4*15 = 540; 4*15 = 60; 15) as the costs of highways, paved roads and improved roads relative to dirt roads, dashed lines in Subfigures 7a and 7b report estimates the total value of the road network over time (in km of dirt roads). Subfigure 7a assumes that all roads in the Nelson and Deichmann (2004) database already existed by 1960, with the stock of dirt roads in year t being equal to the stock of all roads circa 2004 minus the stock of non-dirt roads in t. Subfigure 7b uses the Herbst (2000) data and World Bank (2015a) data from Figure 5 to obtain the stock of roads in each year, with the stock of dirt roads in t being equal to the stock of all roads in t minus the stock of non-dirt roads in t. Since dirt roads are cheap, the two time series are similar, reflecting primarily the evolution of the paved network from 6a. Overall, these figures paint a similar picture of substantial transportation investment until the mid-1980s, followed by limited investment in later decades.

3. Correlates of Network Expansion

We now turn to studying the correlation between transport infrastructure buildout and various economic and non-economic determinants using our new data.

3.1. Specification

We run the following regression, in first differences to control for static country-level factors (which is equivalent to working in levels and including country fixed effects):

$$\Delta I_{c,t} = \rho I_{c,t-5} + \Delta X_{c,t}\alpha + X_{c,t-5}\beta + \lambda_t + \mu_{c,t} \tag{1}$$

where $\Delta I_{c,t}$ is the log change in railroad or road length between years $t-5$ and t in country c. $I_{c,t-5}$ is the initial log railroad or road length in year $t-5$, allowing us to test whether there are increasing returns in transportation infrastructure (i.e., countries with relatively more infrastructure build even more infrastructure) or decreasing returns. $X_{c,t}$ is the set of variables of interest. We include both their initial levels ($X_{c,t-5}$) and first differences ($\Delta X_{c,t}$) where applicable. Year fixed effects (λ_t) control for continent-wide shocks. Standard errors are clustered at the country level.

Our sample is 43 countries over the 11 five-year periods 1960–2015, a total of 473 country-periods. We restrict to five-year periods because our (uninterpolated) roads data are only available every 2.4 years, on average, and some of our covariates are only available every five years. Our four core variables are log per capita GDP (in constant Geary-Khamis \$), log population, the log of the urbanization rate, and log surface area.[12]

Two limitations of this framework are important to note. First, we cannot interpret the estimated coefficients as the causal effects of GDP, population and urbanization on road building. We expect that transport infrastructure has an effect on GDP, population and urbanization, and there are many potential omitted variables correlated with railroads/roads and our covariates, including measures of governance, for example. Rather, they are conditional correlations that help describe the evolution of the transport network. Second, measurement errors are likely to affect both the dependent variables and, more importantly, the variables of interest.

Our econometric framework is similar to Canning (1998), with the same core variables as his Table 5 except that we use log urbanization. However, there are three main differences. First, after investigating these core variables, we consider several more political and economic covariates. Second, we have a long enough panel to consider short differences, whereas Canning (1998) studies the long-difference from 1965 to 1985. Third, after an initial table we focus on paved roads, with limited attention to the total roads and railroads also studied by Canning (1998). Most railroad changes took place before 1960, as shown in Figure 2, and limited data are available for our

[12]Since area is time-invariant, its change is not included. Results are similar if we use unlogged urbanization (available upon request). We also replace zeros with the smallest nonzero value in the sample before logging, to avoid dropping observations with zero values.

covariates of interest before then. Total roads data are less reliable, and after 1960 most road changes involved paving, as shown in Figure 6a.

3.2. Results for the Core Variables of Interest

Baseline. Table 1 shows the conditional associations between the variables and growth in the length of: (1) highways (*highway*), (2) paved roads strictly defined (*paved*), (3) improved roads (*improved*), (4) paved roads including highways (*highway/paved*), (5) paved roads including highways plus improved roads (*non-dirt*), and (6) railroads (*rail*). First, coefficients on the initial level of each type of transportation infrastructure in $t-5$ are proxies for returns to scale in terms of transportation infrastructure. All coefficients are negative, which indicates that countries with less infrastructure tends to build more. We find strong convergence for paved roads (see (2), -0.52***), but little for highways (see (1), -0.06*), since they are still limited to a few richer countries.

Second, in periods with higher initial income, countries build more roads of all types (see (4), 0.31***), though this effect is essentially nil for improved roads (see (3), 0.03). Periods of higher income growth also see more increases in paved roads (see (4), 0.41*), at the expense of the stock of lesser improved roads (see (3), -0.21**). Overall, these results suggest, once one controls for the initial stocks of transportation infrastructure, richer countries disproportionately invest in their paved network broadly defined.

Third, conditional on surface area, countries with larger populations build more highways (see (1), 0.18***), paved roads (see (2), 0.36***) and improved roads (see (3), 0.07**). Countries with faster growing populations build if anything fewer road of all types, though this coefficient is not significant (see (5), -0.25).

Fourth, a high initial level of urbanization, which measures to what extent the population is spatially concentrated in a few urban locations, is disproportionately associated with investments in highways (see (1), 0.18***) and paved roads (see (2), 0.21*). An increase in urbanization is then associated with an expansion of the non-dirt road network (see (5), 0.28**) and rail network (see (6), 0.95**). This is interesting, because spatial concentration could have conversely reduced the need for inter-urban roads and railroads. However, we find that more concentration in cities is associated with more investments in transportation investments, consistent with spatial concentration increasing trade, hence the demand for roads and railroads.

Fifth, physically larger countries expand their non-dirt road network more (see (5), 0.06***). This is manifested most strikingly in the improved road stock (see (3), 0.06**), and decidedly not in highways (see (1), -0.06**), possibly because highways are much more expensive if the objective is simply to have access to remote regions.

Summarizing these results, we find that there is some convergence in all infrastructure stocks conditional on income and population levels and trends. Income growth and initial income, and population and urbanization levels are all associated with more highways and paved roads (columns 1, 2 and 4). Improved roads alone, and non-dirt roads overall (columns 3 and 5) are similarly affected, though faster income growth if anything reduces their stocks (perhaps through conversions). Railroad growth is only strongly correlated with its initial stock (negatively) and change in urbanization (positively). The remainder of our analysis focuses on paved roads exclusively.

Specification Checks. Column (1) of Table 2 reproduces the baseline paved road results (column (4) of Table 1). In columns (2) and (3), we show that results for remaining variables are similar if we drop initial levels or changes, respectively. In columns (4) and (5), results are similar if we include 4 fixed effects for 4 World Bank regions (Central Africa, Eastern Africa, Southern Africa and Western Africa), without and with interactions with the year dummies to control for time-varying heterogeneity at the regional level. In column (5), we are then comparing only neighboring countries in the same region in the same year. Lastly, in column (6), we include country fixed effects, to control for loglinear country-specific trends. Investments still increase more with initial population and urbanization, but the per capita GDP coefficient is insignificant now.

Robustness Checks. Column (1) of Table 3 also reproduces the baseline results (column (4) of Table 1). In column (2), we replace the values of per capita GDP in t and t-5, by their moving average including one year before and after. We do so because per capita GDP can be volatile in African countries, since a large share of their GDP comes from primary commodities whose international prices can dramatically change from year to year. In column (3), we use land area instead of surface area.[13] In column (4), we control for the initial log level and the log growth rate of the urban primacy rate, the share of the largest city in the urban population. A high primacy rate implies that people are more spatially concentrated. Conditional on the effects of urbanization, this could reduce the need for transportation. We do estimate negative coefficients on urban primacy in levels and changes, but they are not significant. In columns (5), (6) and (7), we drop: (i) observations from the early 1960s and the 2010s, for which road length was extrapolated; (ii) observations in the 2000s and 2010s, when we might underestimate road investments; and (iii) South Africa, the wealthiest and most infrastructure-endowed country. Results change very little.[14]

[13] Land area does not include water bodies, which could reduce the need for transportation infrastructure, since it is harder to build on water. However, large water bodies means that transportation networks need to circumvent them, which could increase their total length.

[14] Recall that paved road length in 1960-2015 is extrapolated for 20 countries before 1961 and after 2012,

3.3. Physical Geography, Institutions, and Economic Structure

We now investigate associations with variables proxying for physical geography (Table 4), pre-colonial institutions (Table 5), colonial institutions (Table 6) and post-colonial institutions (Table 7). The first three sets of variables are mostly time-invariant and predetermined with respect to the infrastructure development we study, but they are in some cases poorly measured, both because of conceptual difficulties and because they average over a great deal of subnational variation. Given this, and the fact that a large literature discusses the effect of geography and institutions on our (endogenous) core variables, which in turn account for a substantial fraction of the variance in infrastructure development, we continue to eschew causal interpretation.

Geography. Table 4 shows the individual roles of 8 physical geography variables that could modify the returns but also the costs of building paved roads. We find no association with two variables proxying for coastal access (and thus access to the rest of the world): average distance to the nearest coast (see (1)) and the share of the country that is within 100 km from a coast (see (2)). Likewise, we find no association with variables proxying for geographic isolation, as measured by landlockedness ((3)) and ruggedness ((4)). These characteristics affect both the returns of paved roads and their costs since roads may be more expensive to build when it is more difficult to import the needed materials and equipment and when the terrain is more rugged.

We also investigate the association with land and climate conditions affecting agricultural potential as well as the costs of building and maintaining paved roads. For example, high precipitation makes roads more difficult to maintain.[15] There is no association with soil fertility ((5)), average precipitations ((6)) and the share of land that is a desert ((8)). We could have nonetheless expected a negative association for countries with large desert areas since their population tend to be spatially concentrated. If improved roads are as good as paved roads in dry areas, this could have also lowered the demand for paved roads in such countries. We then find a negative association with the share of tropical area ((7)), but this disappears once we

18 countries before 1965 and after 2014, and 5 countries before 1966 and after 2014. We also verify that results hold when (available upon request): (i) Replacing the extrapolated values by the non-extrapolated value for the closest available year (e.g., 2012 for 2015 for 20 countries); and (ii) Drop the 1960s and the 2010s, since these are the decades for which some of the data is extrapolated.

[15] O'Connor (1978, p.161) writes: "Parts of the West African belt [...] now have a relatively elaborate system of tarred roads, reflecting both climatic conditions which frequently put earth roads out of use [...]. On the other hand, there are many areas, especially in the savannah lands, where even the main roads will be able to withstand any likely traffic in the near future without a tarred surface, but where at present all communications are cut in the rainy season. In many cases only a modest expenditure is required to ensure that the roads do not become impassable under any normal weather conditions."

simultaneously include all the geographical variables (column (9)). Column (9) suggests that geography may not matter much for building paved roads.[16] In column (10), we exclude the core variables. Coastal share and fertility are now positive and significant. This suggests that countries with such characteristics may be wealthier and/or more populated and/or more urbanized, in addition to building more paved roads.[17]

Pre-colonial institutions. Table 5 shows the individual association of 5 variables proxying for pre-colonial institutions that could influence the net benefits of roads. State antiquity, pre-colonial centralization and the urbanization rate circa 1910 reflect political unification and centralization before or toward the beginning of direct colonial control. The scramble for Africa took place in 1885, but European control was quite limited before 1900. Countries with a longer or stronger history of statehood could still have better state capacity today, as in the recent literature on state capacity (Bockstette et al., 2002; Chanda and Putterman, 2007; Besley and Persson, 2009; Borcan et al., 2014; Acemoglu et al., 2015), and this could then condition the willingness and ability of governments to invest in national public goods like roads.

We do not find any association with state antiquity (see (1)) or historical urbanization (see (3)).[18] But we find a strong positive association with centralization (see (2), 0.11***). This result is in line with Gennaioli and Rainer (2007, Table 2 and Fig. 1) who find that more centralized African countries had more paved roads as a share of their road network in 1990-2000. However, in the absence of better roads data, they rely on a cross-sectional regression, and they therefore only capture a level effect, whereas we see potential growth effects in first-differences. The positive sign implies that historically centralized countries build more paved roads over time. This result is also in line with Michalopoulos and Papaioannou (2013) who find a strong association between pre-colonial ethnic political centralization and within-country regional development.

We also investigate whether there is any long-term association between slave exports and road building, as it has been shown that societies that have historically exported

[16]Likewise, we find mostly non-significant association (available upon request) when studying improved roads, non-dirt roads or railroads. The only significant association when simultaneously including all variables is for precipitations that increase the stock of improved roads, possibly because dirt roads are often not passable in countries where it rains a lot, hence the need for improved roads.

[17]We find no association with geography when regressing highway/paved roads, non-dirt roads, improved roads or railroads in 1960 on per capita GDP, population, urbanization and area in 1960, and simultaneously including all geographical variables (N = 43; available upon request). Since there were no railroads before 1862 and motor roads before 1900, these regressions capture long-differences between those years and 1960. But we find negative associations with landlockedness and rainfall and positive associations with ruggedness and tropical area for all roads (incl. dirt roads), when using Herbst (2000)'s data in 1963 (N = 38; available upon request). This suggests that dirt road building depends on geography.

[18]We use the variable with a discount rate of 5%. Results are similar with other discount factors (available upon request): 0%, 0.1%, 1%, 10% and 50%.

more slaves are less trusting today, which could affect their ability to build public goods through collective action (Nunn and Wantchekon, 2011). We do not find any association (see (4)). But we find a strong negative association with ethnic fractionalization, in line with the large literature showing that it may lead to an underprovision of public goods (Easterly and Levine, 1997; Alesina et al., 2003, 2014). When simultaneously including all these variables (see (6)), the coefficients on centralization and fractionalization fall by 25–30% but remain significant at conventional levels despite larger standard errors.[19]

If we drop the core variables (see (7)), we find that slave exports now have a positive association (0.05***). This seems to be explained by the positive correlations between the number of slaves exported and population, urbanization and area, which are themselves positively correlated with paved road building.[20]

Colonial institutions. Table 6 shows the individual associations with 6 variables proxying for colonial institutions that could influence the net benefits of roads. In column (1) and column (2), we include the settler mortality rate and the share of the population that is of European descent. We find no association with the former, but a strong one with the later (0.21***). If the countries that received more Europeans had better institutions during the colonial period that persisted, as argued by Acemoglu et al. (2001) and Putterman and Weil (2010), these institutions could have allowed these countries to build more roads post-1960. Former French colonies built more roads relative to other non-English colonies (0.28***), but this relationship disappears once we control for the other colonial factors (see (6)). In column (4), we find no difference for countries with French legal origins (which combines French with some former Belgian, Portuguese and Spanish colonies). In column (5), we find no difference for countries that were still a colony in year $t-5$ (almost half of the sample became independent after 1960). The European descent coefficient remains positive and significant when including all controls (see (6)). Interestingly, when we do not control for the core variables, we find that former English colonies were building more roads post-1960 (see (7), 0.27**). The fact that this association disappears once we control for income, population and urbanization suggests that these countries were building more roads

[19]We find no significant associations for improved roads (available upon request). For railroads, we find negative correlations with both ethnic fractionalization and centralization, although the negative correlation with centralization is small and barely significant. This could suggest that historically centralized countries have been transitioning from railroads to paved roads relatively faster post-1960.

[20]We find no significant associations when regressing highway/paved roads, non-dirt roads, improved roads or railroads in 1960 on per capita GDP, population, urbanization and area in 1960, and simultaneously including all pre-colonial institutions variables (N = 43; available upon request). But we find a positive and significant association with centralization for all roads (incl. dirt roads) when using Herbst (2000)'s data in 1963 (N = 38). Centralization was essential for building tracks (Herbst, 2000).

simply because they were more developed or populated.[21]

Post-colonial institutions and economic structure. Table 7 shows the individual coefficients of several variables proxying for post-colonial institutions and economic structure. In columns (1) and (2), we find that countries that were initially non-autocratic (see (1), 0.17, only significant at 15%) or fully democratic (see (2), 0.24**) built more roads. We find no association with rule of law (see (3)) or conflict (see (4)).[22]

Many African countries are specialized in the export of natural resources, which may have effects on institutions beyond their economic effects on GDP or urbanization, or may also lead to the development of either general transport infrastructure or specialized transport infrastructure (to the detriment of the remainder of the transport system). In column (5), we find that countries with a high initial share of natural resource exports in merchandise exports build fewer roads (-0.13, but only significant at 15%), conditional on the ratio of merchandise exports to GDP. However, when natural resources are split into minerals (6) and agriculture (7), not surprisingly only minerals have a negative coefficient (see (6), -0.07**). This is consistent with a "resource curse" often associated with worse institutions (Robinson et al., 2006; Mehlum et al., 2006; Vicente, 2010). The underinvestments in roads could also be part of a strategy to isolate the capital/largest city, where political power and resource rents are concentrated, from the rest of the country, consistent with the literature on the political determinants of geographical isolation (Herbst, 2000; Campante and Do, 2014; Campante et al., 2013). As Herbst (2000, p.170) puts it: "building roads is literally a two-way street: roads allow the capital to reach outward but also allow those in the hinterland to march more quickly to the center or power. In fact, a not illogical strategy for many leaders confronting vast territories would be to try not to reach out to outlying areas and let these areas that want to threaten the state live in relative isolation."[23]

[21]We find no significant associations with both improved roads and railroads in 1960-2015 (available upon request). When regressing highway/paved roads, non-dirt roads, improved roads or railroads in 1960 on per capita GDP, population, urbanization and area in 1960, and simultaneously including all colonial institutions variables (N = 42; available upon request), we find a positive significant association with still being a colony in 1960 for both railroads and paved roads. No significant association is found for all roads (incl. dirt roads) when using Herbst (2000)'s data in 1963 (N = 38).

[22]The non-result for conflict is robust to only using interstate or intrastate conflicts, or using measures proxying for conflict intensity (available upon request). Conflicts destroy roads. At the same time, nation-states may need to build roads to defend themselves against external threats. Herbst (2000, p.170) writes: "countries that face external threats have to tie their forward areas that have direct responsibility for confronting enemies to the political core. As a result, they have a profound incentive to build roads." However, we do not find any significant association with conflict. The non-result for rule of law is then robust to using other measures from the *World Governance Indicators* database of the World Bank (2015b), such as government effectiveness, regulatory quality and control of corruption (available upon request).

[23]One could have thought the export of mineral resources would have required more roads, but it is not necessarily the case ceteris paribus. Most oil in Africa is produced very near the coast or offshore. Some

Lastly, when we simultaneously include all variables (see (8)), the democracy coefficient decreases and is only significant at 15% (p-value of 0.112). Removing the core variables has less impact here (see (9)). Interestingly, when investigating the building of improved roads, we only find a positive and significant coefficient for the export share of agricultural products (0.03***, not shown but available upon request). In countries with a strong cash crop sector, it is possible that the government builds more improved roads in order to open more areas for cash crop cultivation, but the government does so by building roads that are cheaper than paved roads. No association is found for democracy and mining exports on improved roads or railroads (available upon request).

Table 8 considers resource exports as a fraction of GDP directly.[24] We include all the core controls of Table 1 except the change and initial level of per capita GDP. In column (1), we show that initial levels of both resource and non-resource per capita GDP are positively correlated with more roads. In column (2), when separating per capita GDP into mining (including fuels) and non-mining portions, we actually find a negative association with economic growth due to mining (-0.04**) and no association at all with the initial level of mining-based GDP (0.02). Likewise, in column (3), we also find that per capita GDP coming from agricultural exports (i.e. cash crops) does not lead to investments in roads. Lastly, in column (4), we simultaneously compare the level and growth associations with non-resource-based GDP, mining-based GDP and cash crop-based GDP, and find that results shown in the other columns are robust when doing so. Again, it is the non-natural resource income and growth that is positively correlated with road development. These results are in line with the result shown in Table 7 that shows that a higher export share of mineral resources is associated with fewer paved road investments. Interestingly, when investigating the building of improved roads, we also find a positive association with agricultural exports as a fraction of GDP (0.03***, not shown but available upon request). When studying railroad building, we then find a positive association with mining exports as a fraction of GDP (0.02**, available upon request), which suggests that mining-rich countries invest in specialized transport infrastructure, possibly to the detriment of the remainder of the transport system. As explained by Jedwab and Moradi (2016), railroads only transported a small share of sub-Saharan Africa's freight and passenger traffic throughout the post-independence period.

All variables. In Table 9, we repeat the individual-variable specifications from Tables 4–8 for variables that were significantly correlated with road development (at 10%)

mineral resources are light (e.g., diamonds and gold). And heavier mineral resources such as bauxite and iron ore often rely on colonial or early post-independence railroad networks.

[24]Note that these are not GDP shares of these sectors per se, as they do not net out the costs.

conditional on core variables and all other variables in their respective tables (in levels and changes, where applicable), plus democracy (which likely had muted effects in the omnibus specification because of multicollinearity) and the share of merchandise exports in GDP (without which the share of mineral exports in merchandise exports is less interpretable). These variables are pre-colonial centralization (see (1)), ethnic fractionalization ((2)), share of population of European descent ((3)), the change and initial level of the democracy dummy ((4)), and the share of mineral resource exports in merchandise exports conditional on the share of merchandise exports in GDP ((5)). In column (6), we simultaneously include all these variables. Results are similar, although the fractionalization coefficient becomes smaller and insignificant. In columns (7) and (8), we include 4 region fixed effects and 44 region-year fixed effects respectively, so as to only compare countries in the same region over time. Only the region-year fixed effects remove enough variation to affect point estimates on democracy and mining substantially, decreasing them by a third.[25] Overall, non-economic factors, and not just purely economic and demographic factors, are correlated with investments.

3.4. Central vs. Peripheral Regions

Our last empirical exercise is to consider how the covariates are related to the placement of roads along one particular dimension: centrality with respect to large cities.

Data and background. Using the GIS railroad and road data from Jedwab and Storeygard (2017) shown in Subfigures 1a and 1b, we obtain the total length of highway/paved roads being built in the central and peripheral region of each of the 43 countries from 1960 to 2015. To define the central region, we use the work of Jedwab and Storeygard (2017) that divides each country into grid cells of 0.1x0.1 degrees (11x11km) and obtain the distance from the cell's centroid to the nearest large city, defined as the country's capital in 1960 and 2010 and its two largest cities in 1960. Knowing each cell's distance to these cities, we divide all cells into two regions: "central" if the distance is below the median in the country and "peripheral" if the distance is above the median. We then obtain the total length of highway/paved for each country-region-year.

During the colonial era, European powers disproportionately built railroads and roads in the central regions. For example, Herbst (2000, p.167) writes: "The colonialists essentially built the minimum number of roads necessary to rule given the Berlin rules [...] they only addressed the fixed costs that had to be paid in order to rule the capital. That means that colonies with large geographic masses had relatively low road

[25] We find no significant associations for improved roads and railroads except for centralization, which has a negative association with the stock of both (available upon request). This suggests that centralized countries are more likely to invest in the best transportation technology, i.e. highways/paved roads.

stock because most of the road building under white rule was concentrated around the capital." Figure 8 shows paved road length for all central and peripheral regions, as well as the percentage share of the central paved road network in the total paved road network, from 1960 to 2015. It shows that central regions had more paved roads initially, almost 80% of them in 1960. There has then been some decentralization since 1960. For example, O'Connor (1978, p.156) writes: "Since the traffic is generally heavily concentrated in the most developed parts of each country, it is there that most improvements have been made: but at the same time many new highways [paved roads] have been built into less developed districts." However, the paved road network is still concentrated, with over 70% of it in the central half of countries today.

Specification. We run the following regression:

$$\Delta I_{c,r,t} = \rho I_{c,r,t-5} + \Delta X_{c,t}\alpha + X_{c,t-5}\beta + \varphi_r + \lambda_t + \mu_{c,r,t} \tag{2}$$

where c, r, and t index countries, regions (central/peripheral), and years, respectively. $\Delta I_{c,r,t}$ is the log change in railroad or road length between year $t-5$ and year t and $I_{c,r,t-5}$ is the initial log railroad or road length in year $t-5$. φ_r is a dummy equal to one if region r is peripheral. The remaining variables are defined at the country-year level as in equation (1), and standard errors are again clustered at the country level. Since we have 42 countries, 2 regions, and 11 periods, the sample is 924 observations.[26]

Baseline results. In Table 10, we show conditional correlations with the core variables, the far dummy, and the interactions of the dummy and the core variables, on the same outcomes as Table 1: the length of highways (see (1)), paved roads ((2)), improved roads ((3)), highway/paved roads ((4)), non-dirt roads ((5)) and railroads ((6)). Overall, the associations in the central regions (i.e., the non-interacted effects) are fairly similar to the Table 1 ones for the overall country. That is not surprising if most paved roads are located in the central region. We thus only discuss the the peripheral region results.

Countries that are initially more populated do not build more highways in far areas (see (1), -0.07**), even though they do so in near areas ((1), 0.11**). The positive relationship between urbanization and surface area and paved and improved roads in central areas (see (2)-(3)) is similarly negated in peripheral areas. Larger and more urbanized countries do build more roads, but only in the half of the country near big cities. However, in countries where total population grows faster we observe more investments in paved roads in peripheral areas than in central areas ((2), 2.19***), with some of these newly paved roads perhaps having been formerly improved roads ((3), -0.63*). This is consistent with countries with fast-growing populations building access

[26]Madagascar was not included in the analysis of Jedwab and Storeygard (2017).

to and exploiting more land to accommodate them. Likewise, in countries where the urban share is increasing more, one sees more investments in peripheral than central non-dirt roads ((5), 0.70**). Lastly, peripheral regions appear to receive more highways (see (1), 1.62**), but this positive relationship only appears because we are controlling for the core variables and their interactions with the far dummy. When only including the far dummy, its association is strongly negative (not shown).

Other variables. In Table 11, we interact the Table 9 specifications with the far dummy to study the relative associations of other economic and historical factors in the peripheral regions (we also control for the far dummy and the interacted effects of the dummy and the core variables). The (non-interacted) associations for the central regions are similar to those for the whole country (Table 9), due to most paved roads being located in the central regions. Thus, we only discuss the peripheral region results.

Column (1) shows that countries with a high degree of centralization have more roads in both the central and peripheral regions (the interacted coefficient is not significantly different from 0). Peripheral regions may thus also benefit in a historically more centralized society. Column (2) shows that ethnic fractionalization only has negative associations in the central regions (since the interacted effect cancels out the non-interacted effect). The literature on fractionalization has also shown that, within a country, a higher level of ethnic diversity is associated with significant underprovision of public goods (Miguel and Gugerty, 2005; Habyarimana et al., 2007; Alesina et al., 2014). In our context, we could expect the central regions to exhibit a higher level of ethnic diversity, due to the fact that the capital and largest cities tend to attract people from multiple ethnic groups. Peripheral regions may also have multiple ethnic groups in them, but they are more likely to be spatially segregated. In that case, countries with a higher level of fractionalization would see more underinvestment in roads in their central regions relative to their peripheral regions.

Column (3) shows a positive association with a high share of European descendants, for both regions (the interacted coefficient is not significantly different from 0). Column (4) shows positive associations with of being a democratic country, but for the central regions only (0.27*** and -0.20*). While one could have expected some decentralization effects of democracy, in democratic systems incumbent governments could disproportionately target urban voters and thus the central regions (since each dollar spent on roads could affect more voters). This is in line with Herbst (2000, p.170) who writes: "Instead of spending money on roads [in outlying areas] to secure their authority, African leaders [...] have strong incentives to engage in patronage politics at the center." Also, if central regions are more ethnically diverse, and there is ethnic favoritism and democracy prevents presidents from only building roads in their ethnic homelands (Burgess et al., 2015), democracy should reallocate road investments to the central regions. Likewise, democratization episodes if anything disproportionately favor the central regions (-0.33* for the peripheral regions relative to the central regions).

Column (5) shows a negative association with mining exports for the central regions (-0.08**), but less so in the peripheral regions (0.09, although not significant). It could be that mining-rich countries still build roads in peripheral regions, especially if they need to access the mines or oil fields there. Or it could be that their governments are more corrupt, and underprovide roads to its most populated areas (i.e. the central regions) or simply build fewer roads around the capital/largest city to isolate themselves from the rest of the country and thus protect their resource rents (Herbst, 2000).

If we simultaneously include all variables (6), with region fixed effects (7) or region-year fixed effects (8), the positive centralization coefficient (0.03-0.04) and the negative democracy coefficient in the far regions (-0.15) become insignificant. The coefficient of the population share with European descent for the far regions becomes positive (0.19**–0.20**). This could suggest that countries with a high share of European descendants seek to develop their peripheral regions, possibly because they have more (spatially) “inclusive” institutions, in line with the literature on European settlement, institutions and development (Acemoglu et al., 2001; Putterman and Weil, 2010).[27]

4. Conclusion

In this paper, we have introduced two new datasets on the evolution of African railroads and paved roads. We have shown that they match well with existing data sources but enhance them with greater coverage and detail, allowing us to paint a fuller picture of the history of African transport infrastructure. African countries with larger total and urban populations and incomes and higher income and urban growth build more roads. Furthermore, several institutional features contribute to paved road investment. Centralization and European settlement are consistently associated with more paved road construction, as is democracy. Mineral dependence and ethnic fractionalization are associated with reduced paved road construction. If these relationships continue to hold, we expect that the many planned road projects throughout the continent

[27]When investigating railroads and improved roads, we find that centralization has a negative association with the stock of both (available upon request). These negative coefficients combined with the positive coefficient for paved roads suggests that centralized countries are more likely to invest in the best transportation technology of the time, i.e. highways/paved roads, and this in both the central and peripheral regions. In addition, countries that are more democratic initially get more improved roads in their central regions, possibly because they provide a cheaper way to reach more urban voters.

will be more successfully built in countries with better institutions. Increases in democratic governance may make this more feasible. However, different funding mechanisms, including increased participation by private investors and Chinese aid, further urbanization, and changing trade relationships may result in different patterns of actual road and rail construction. It will be important for future work to reassess this relationship in the new economic and political environment.

REFERENCES

Acemoglu, Daron, Camilo García-Jimeno, and James A. Robinson (2015) "State Capacity and Economic Development: A Network Approach," *American Economic Review*, Vol. 105, No. 8, pp. 2364–2409.

Acemoglu, Daron, Simon Johnson, and James A. Robinson (2001) "The Colonial Origins of Comparative Development: An Empirical Investigation," *American Economic Review*, Vol. 91, No. 5, pp. 1369–1401.

Acemoglu, Daron, Suresh Naidu, Pascual Restrepo, and James A. Robinson (forthcoming) "Democracy Does Cause Growth," *Journal of Political Economy*.

Acemoglu, Daron and James A. Robinson (2010) "Why is Africa Poor?" *Economic History of Developing Regions*, Vol. 25, No. 1 June 2010, pp. 21–50.

African Development Bank (2012–2015) *Annual Report*, Abidjan/Tunis: African Development Bank.

——— (2015) *Rail Infrastructure in Africa: Financing Policy Options*, Abidjan: African Development Bank.

Alesina, Alberto, Reza Baqir, and William Easterly (1999) "Public Goods and Ethnic Divisions," *The Quarterly Journal of Economics*, Vol. 114, No. 4, pp. 1243–1284.

Alesina, Alberto, Arnaud Devleeschauwer, William Easterly, Sergio Kurlat, and Romain Wacziarg (2003) "Fractionalization," *Journal of Economic Growth*, Vol. 8, No. 2, pp. 155–194.

Alesina, Alberto, Caterina Gennaioli, and Stefania Lovo (2014) "Public Goods and Ethnic Diversity: Evidence from Deforestation in Indonesia," NBER Working Papers 20504, National Bureau of Economic Research, Inc.

Alesina, Alberto, Stelios Michalopoulos, and Elias Papaioannou (2016) "Ethnic Inequality," *Journal of Political Economy*, Vol. 124, No. 2, pp. 428–488.

Alexeeva, Victoria, Gouthami Padam, and Cesar Queiroz (2008) "Monitoring Road Works Contracts and Unit Costs for Enhanced Governance in Sub-Saharan Africa," Transport Papers TP-21, World Bank.

Amjadi, Azita and Alexander J. Yeats (1995) "Have transport costs contributed to the relative decline of sub-Saharan African exports? Some preliminary empirical evidence," Policy Research Working Paper Series 1559, The World Bank.

Asher, Samuel and Paul Novosad (2016) "Market Access and Structural Transformation: Evidence from Rural Roads in India," mimeo, Dartmouth College.

Atkin, David and Dave Donaldson (2015) "Who's Getting Globalized? The Size and Implications of Intranational Trade Costs," NBER Working Papers 21439, National Bureau of Economic Research, Inc.

Barro, Robert J (1996) "Democracy and Growth," *Journal of Economic Growth*, Vol. 1, No. 1, pp. 1–27.

Berg, Claudia N., Brian Blankespoor, and Harris Selod (2016) "Roads and rural development in Sub-Saharan Africa," Policy Research Working Paper Series 7729, The World Bank.

Berg, Claudia N., Uwe Deichmann, Yishen Liu, and Harris Selod (2017) "Transport Policies and Development," *The Journal of Development Studies*, Vol. 0, No. 0, pp. 1–16.

Besley, Timothy and Torsten Persson (2009) "The Origins of State Capacity: Property Rights, Taxation, and Politics," *American Economic Review*, Vol. 99, No. 4, pp. 1218–44.

Bird, Julia and Stephane Straub (2014) "The Brasilia experiment : road access and the spatial pattern of long-term local development in Brazil," Policy Research Working Paper Series 6964, The World Bank.

Bockstette, Valerie, Areendam Chanda, and Louis Putterman (2002) "States and Markets: The Advantage of an Early Start," *Journal of Economic Growth*, Vol. 7, No. 4, pp. 347–69.

Bolt, Jutta and Jan Luiten van Zanden (2014) "The Maddison Project: collaborative research on historical national accounts," *Economic History Review*, Vol. 67, No. 3, pp. 627–651.

Borcan, Oana, Ola Olsson, and Louis Putterman (2014) "State History and Economic Development: Evidence from Six Millennia," Working Papers in Economics 602, University of Gothenburg, Department of Economics.

Buonanno, Paolo, Ruben Durante, Giovanni Prarolo, and Paolo Vanin (2015) "Poor Institutions, Rich Mines: Resource Curse in the Origins of the Sicilian Mafia," *The Economic Journal*, Vol. 125, No. 586, pp. F175–F202.

Burgess, Robin, Rémi Jedwab, Edward Miguel, Ameet Morjaria, and Gerard Padró i Miquel (2015) "The Value of Democracy: Evidence from Road Building in Kenya," *American Economic Review*, Vol. 105, No. 6, pp. 1817–51.

Buys, Piet, Uwe Deichmann, and David Wheeler (2010) "Road Network Upgrading and Overland Trade Expansion in Sub-Saharan Africa-super- ," *Journal of African Economies*, Vol. 19, No. 3, pp. 399–432.

Calderón, César and Luis Servén (2010) "Infrastructure and Economic Development in Sub-Saharan Africa," *Journal of African Economies*, Vol. 19, No. suppl 1, pp. 13–87.

——— (2014) "Infrastructure, growth, and inequality : an overview," Policy Research Working Paper Series 7034, The World Bank.

Campante, Filipe R. and Quoc-Anh Do (2014) "Isolated Capital Cities, Accountability, and Corruption: Evidence from US States," *American Economic Review*, Vol. 104, No. 8, pp. 2456–81.

Campante, Filipe R., Quoc-Anh Do, and Bernardo V. Guimaraes (2013) "Isolated Capital Cities and Misgovernance: Theory and Evidence," NBER Working Papers 19028, National Bureau of Economic Research, Inc.

Canning, David (1998) "A Database of World Stocks of Infrastructure, 1950-95," *The World Bank Economic Review*, Vol. 12, No. 3, pp. 529–547.

——— (1999) "Infrastructure's contribution to aggregate output," Policy Research Working Paper Series 2246, The World Bank.

Canning, David and Esra Bennathan (2000) "The social rate of return on infrastructure investments," Policy Research Working Paper Series 2390, The World Bank.

Canning, David and Mansour Farahani (2007) "A Database of World Stocks of Infrastructure: Update 1950-2005," mimeo, Harvard School of Public Health.

Canning, David and Peter Pedroni (2008) "INFRASTRUCTURE, LONG-RUN ECONOMIC GROWTH AND CAUSALITY TESTS FOR COINTEGRATED PANELS," *The Manchester School*, Vol. 76, No. 5, pp. 504–527.

Center for Systemic Peace (2015a) *Major Episodes of Political Violence, 1946-2015*, Vienna, VA.

——— (2015b) *Polity IV Annual Time-Series, 1800-2015*, Vienna, VA.

Chaléard, Jean-Louis, Chantal Chanson-Jabeur, and Chantal Béranger (2006) *Le chemin de fer en Afrique*, Paris: Karthala Editions.

Chanda, Areendam and Louis Putterman (2007) "Early Starts, Reversals and Catch-up in the Process of Economic Development," *Scandinavian Journal of Economics*, Vol. 109, No. 2, pp. 387–413.

Chaves, Isaias, Stanley L. Engerman, and James A. Robinson (2014) "Reinventing the Wheel: The Economic Benefits of Wheeled Transportation in Early Colonial British West Africa," in Emmanuel Akyeampong, Robert H. Bates, Nathan Nunn, and James Robinson eds. *Africa's Development in Historical Perspective*: Cambridge University Press, pp. 321–365.

Collier, Paul, Martina Kirchberger, and Måns Söderbom (2015) "The Cost of Road Infrastructure in Low and Middle Income Countries," *The World Bank Economic Review*, Vol. 30, No. 3, pp. 522–548.

Communaute Economique Europeenne (1966) "Possibilités d'industrialisation des Etats africains et malgache associés,"Technical report, Communaute Economique Europeenne.

Depetris-Chauvin, Emilio and Ruben Durante (2017) "One Team, One Nation: Football, Ethnic Identity, and Conflict in Africa," CEPR Discussion Papers 12233, C.E.P.R. Discussion Papers.

Dierks, Klaus (2001) “Namibian Roads in History: From the 13th Century till Today,” mimeo, Goethe-Universität Frankfurt/Main.

Donaldson, Dave (forthcoming) “Railroads of the Raj: Estimating the Impact of Transportation Infrastructure,” *American Economic Review*.

Easterly, William and Ross Levine (1997) “Africa’s Growth Tragedy: Policies and Ethnic Divisions,” *The Quarterly Journal of Economics*, Vol. 112, No. 4, pp. 1203–1250.

Ekundare, Olufemi (1973) *An Economic History of Nigeria 1860-1960*, New York: Holmes & Meier.

Faber, Benjamin (2014) “Trade Integration, Market Size, and Industrialization: Evidence from China’s National Trunk Highway System,” *The Review of Economic Studies*, Vol. 81, No. 3, pp. 1046–1070.

Fenske, James (2013) “Does Land Abundance Explain African Institutions?” *The Economic Journal*, Vol. 123, No. 573, pp. 1363–1390.

Fenske, James and Igor Zurimendi (2015) “Oil and ethnic inequality in Nigeria,”Technical report.

Fourie, Johan, Alfonso Herranz-Loncan, and Alfonso Herranz-Loncan (2015) “Growth (and Segregation) by Rail: How the Railways Shaped Colonial South Africa,” Working Papers 538, Economic Research Southern Africa.

Gennaioli, Nicola and Ilia Rainer (2007) “The modern impact of precolonial centralization in Africa,” *Journal of Economic Growth*, Vol. 12, No. 3, pp. 185–234.

Gewald, Jan-Bart, Sabine Luning, and Klaas van Walraven eds. (2009) *The Speed of Change: Motor Vehicles and People in Africa, 1890-2000* in , Afrika-Studiecentrum Series, No. 13, Leiden: Brill.

Ghani, Ejaz, Arti Grover Goswami, and William R. Kerr (2016) “Highway to Success: The Impact of the Golden Quadrilateral Project for the Location and Performance of Indian Manufacturing,” *Economic Journal*, Vol. 126, No. 591, pp. 317–357.

Gollin, Doug, Rémi Jedwab, and Dietrich Vollrath (2016) “Urbanization with and without Industrialization,” *Journal of Economic Growth*, Vol. 21, No. 1, pp. 35–70.

Government of China (2016) *Transportation Overview*, Beijing, China: Ministry of Transport of the People’s Republic.

Government of India (2016) *Basic Road Statistics of India 2013-14 and 2014-15*, Delhi, India: Ministry of Road Transport & Highways.

Gutman, Jeffrey, Amadou Sy, and Soumya Chattopadhya (2015) *Financing African Infrastructure: Can the World Deliver?*, Washington: The Brookings Institution.

Gwilliam, Ken (2011) *Africa’s Transport Infrastructure: Mainstreaming Maintenance and Management*, Washington: World Bank.

Habyarimana, James, Macartan Humphreys, Daniel Posner, and Jeremy Weinstein (2007) “Why Does Ethnic Diversity Undermine Public Goods Provision? An Experimental Approach,” *American Political Science Review*, Vol. 101, No. 4, pp. 709–725.

Harrison, David (1995) “Development of Tourism in Swaziland,” *Annals of Tourism Research*, Vol. 22, No. 1, pp. 135–156.

Heap, Simon (1990) “The Development of Motor Transport in the Gold Coast, 1900-1939,” *Journal of Transport History*, Vol. 11, No. 2, pp. 19–37.

Herbst, Jeffrey (2000) *States and Power in Africa: Comparative Lessons in Authority and Control*, Princeton, N.J.: Princeton University Press.

Jedwab, Rémi (2013) “Urbanization without Industrialization: Evidence from Consumption Cities in Africa,” mimeo, The George Washington University.

Jedwab, Remi, Edward Kerby, and Alexander Moradi (2017) “History, Path Dependence and Development: Evidence from Colonial Railways, Settlers and Cities in Kenya,” *The Economic Journal*, pp. n/a–n/a.

Jedwab, Rémi and Alexander Moradi (2016) “The Permanent Economic Effects of Transportation Revolutions in Poor Countries: Evidence from Africa,” *Review of Economics and Statistics*, Vol. 98, No. 2, pp. 268–284.

Jedwab, Rémi and Adam Storeygard (2017) “The Heterogeneous Effects of Transportation Investments: Evidence from sub-Saharan Africa 1960-2010,” mimeo, George Washington University.

La Porta, Rafael, Florencio Lopez-de Silanes, and Andrei Shleifer (2008) "The Economic Consequences of Legal Origins," *Journal of Economic Literature*, Vol. 46, No. 2, pp. 285–332.

Limão, Nuno and Anthony J. Venables (2001) "Infrastructure, Geographical Disadvantage, Transport Costs, and Trade," *The World Bank Economic Review*, Vol. 15, No. 3, pp. 451–479.

Lled, Victor D., Irene Yackovlev, and Lucie Gadenne (2011) "A Tale of Cyclicality, Aid Flows and Debt: Government Spending in Sub-Saharan Africa," *Journal of African Economies*, Vol. 20, No. 5, pp. 823–849.

Maddison, Angus (2008) *Maddison Project Database*, http://www.ggdc.net/maddison/maddison-project/orihome.htm.

Manning, Patrick (2015) "African Population, 1650-2000: Comparisons and Implications of New Estimates," in Emmanuel Akyeampong, Robert Bates, Nathan Nunn, and James Robinson eds. *Africa's Development in Historical Perspective*: Cambridge University Press.

Mehlum, Halvor, Karl Moene, and Ragnar Torvik (2006) "Institutions and the Resource Curse," *Economic Journal*, Vol. 116, No. 508, pp. 1–20.

Michalopoulos, Stelios and Elias Papaioannou (2013) "Pre-Colonial Ethnic Institutions and Contemporary African Development," *Econometrica*, Vol. 81, No. 1, pp. 113–152.

——— (2014) "National Institutions and Subnational Development in Africa," *The Quarterly Journal of Economics*, Vol. 129, No. 1, pp. 151–213.

——— (2015) "On the Ethnic Origins of African Development: Traditional Chiefs and Pre-colonial Political Centralization ," *Academy of Management Perspectives*, Vol. 29, No. 1, pp. 32–71.

——— (2016) "The Long-Run Effects of the Scramble for Africa," *American Economic Review*, Vol. 106, No. 7, pp. 1802–48.

Miguel, Edward and Mary Kay Gugerty (2005) "Ethnic diversity, social sanctions, and public goods in Kenya," *Journal of Public Economics*, Vol. 89, No. 11-12, pp. 2325–2368.

Mitchell, B. R. (1995) *International Historical Statistics: Africa, Asia, and Oceania, 1750-1988*, New York: Stockton Press, 2nd edition.

Mlambo, Alois (1994) "From Dirt Tracks to Modern Highways: Towards a History of Roads and Road Transportation in Colonial Zimbabwe, 1890 to World War II," *Zambezia*, Vol. 21, No. 2, pp. 147–166.

Nelson, Andrew and Uwe Deichmann (2004) "African Population database documentation,"Technical report, United Nations Environment Programme and CIESIN at Columbia University.

Nunn, Nathan (2008) "The Long-term Effects of Africa's Slave Trades," *The Quarterly Journal of Economics*, Vol. 123, No. 1, pp. 139–176.

Nunn, Nathan and Diego Puga (2012) "Ruggedness: The Blessing of Bad Geography in Africa," *The Review of Economics and Statistics*, Vol. 94, No. 1, pp. 20–36.

Nunn, Nathan and Leonard Wantchekon (2011) "The Slave Trade and the Origins of Mistrust in Africa," *American Economic Review*, Vol. 101, No. 7, pp. 3221–52.

O'Connor, Anthony (1971) *The Geography of Tropical African Development*, Headington Hill Hall, Oxford: Pergamon Press Ltd.

——— (1978) *The Geography of Tropical African Development: 2nd Edition*, Headington Hill Hall, Oxford: Pergamon Press Ltd.

Ogonda, R. T. (1992) "Transport and communications in the colonial economy," in William Robert Ochieng' and Robert M. Maxon eds. *An economic history of Kenya*: East African Educational Publishers, pp. 129–145.

Papaioannou, Elias and Gregorios Siourounis (2008) "Democratisation and Growth," *Economic Journal*, Vol. 118, No. 532, pp. 1520–1551.

Pedersen, Poul Ove (2001) "The Freight Transport and Logistical System of Ghana," Working Paper 01.2, Centre for Development Research in Copenhagen.

Perkins, Peter (2003) "An analysis of economic infrastructure investment in South Africa," Ph.D. dissertation, University of the Witwatersrand, Johannesburg.

Perkins, Peter, Johann Fedderke, and John Luiz (2005) "An Analysis of Economic Infrastructure Investment in South Africa," *South African Journal of Economics*, Vol. 73, No. 2, pp. 211–228.

Persson, Torsten and Guido Tabellini (2006) "Democracy and Development: The Devil in the Details," *American Economic Review*, Vol. 96, No. 2, pp. 319–324.

Putterman, Louis and David N. Weil (2010) "Post-1500 Population Flows and The Long-Run Determinants of Economic Growth and Inequality," *The Quarterly Journal of Economics*, Vol. 125, No. 4, pp. 1627–1682.

Radelet, Steven and Jeffrey D. Sachs (1998) "Shipping Costs, Manufactured Exports, and Economic Growth," mimeo, The World Bank.

Robinson, James A., Ragnar Torvik, and Thierry Verdier (2006) "Political foundations of the resource curse," *Journal of Development Economics*, Vol. 79, No. 2, pp. 447–468.

Rodrigue, J-P (2017) *The Geography of Transport Systems*, New York: Routledge, 4th edition.

Sala-i-Martin, Xavier (1997) "I Just Ran Two Million Regressions," *American Economic Review*, Vol. 87, No. 2, pp. 178–83.

Soja, Edward W. (1968) *The Geography of Modernization in Kenya: A Spatial Analysis of Social, Economic, and Political Change*, Syracuse, NY: Syracuse University Press.

Storeygard, Adam (2016) "Farther on Down the Road: Transport Costs, Trade and Urban Growth in sub-Saharan Africa," *Review of Economic Studies*, Vol. 83, No. 3, pp. 1263–1295.

The Economist (2015) *All Aboard*, London, United Kingdom: The Economist.

Thornton, John (2008) "Explaining Procyclical Fiscal Policy in African Countries," *Journal of African Economies*, Vol. 17, No. 3, p. 451.

Um, Paul Noumba, Stephane Straub, and Charles Vellutini (2009) "Infrastructure and economic growth in the Middle East and North Africa," Policy Research Working Paper Series 5105, The World Bank.

United Nations (2015a) *World Population Prospects: The 2015 Revision*, New York: United Nations, Department of Economic and Social Affairs.

——— (2015b) *World Urbanization Prospects: The 2014 Revision*, New York: United Nations.

Vicente, Pedro C. (2010) "Does oil corrupt? Evidence from a natural experiment in West Africa," *Journal of Development Economics*, Vol. 92, No. 1, pp. 28–38.

Wilburn, Kenneth (1982) "The Climax of Railway Competition in South Africa, 1886-1899," Ph.D. dissertation, University of Oxford Press.

World Bank (2006) *World Development Indicators*, Washington: World Bank.

——— (2010) *Africa's infrastructure: a time for transformation*, Washington: World Bank.

——— (2015a) *World Development Indicators*, Washington: World Bank.

——— (2015b) *World Government Indicators*, Washington: World Bank.

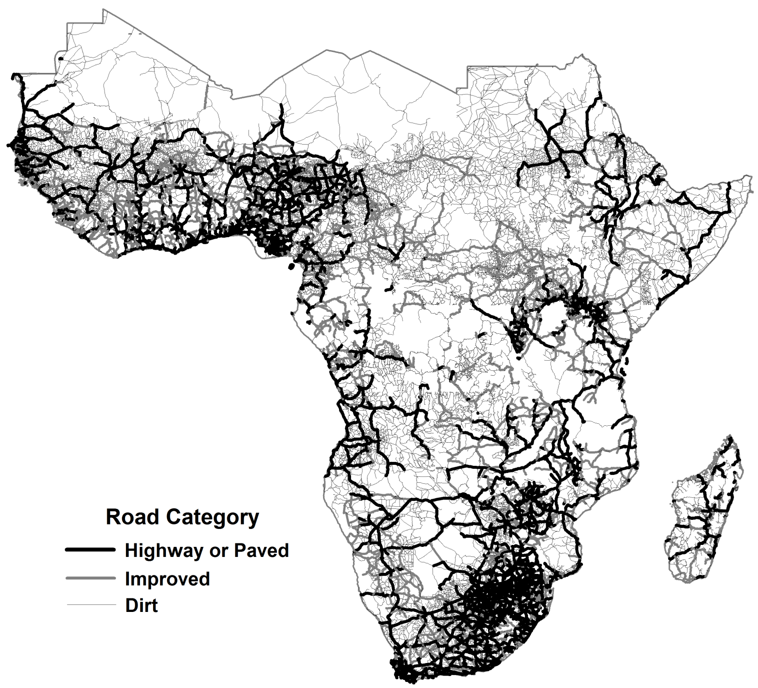
——— (2016a) *Annual Report*, Washington: World Bank.

——— (2016b) *World Development Indicators*, Washington: World Bank.

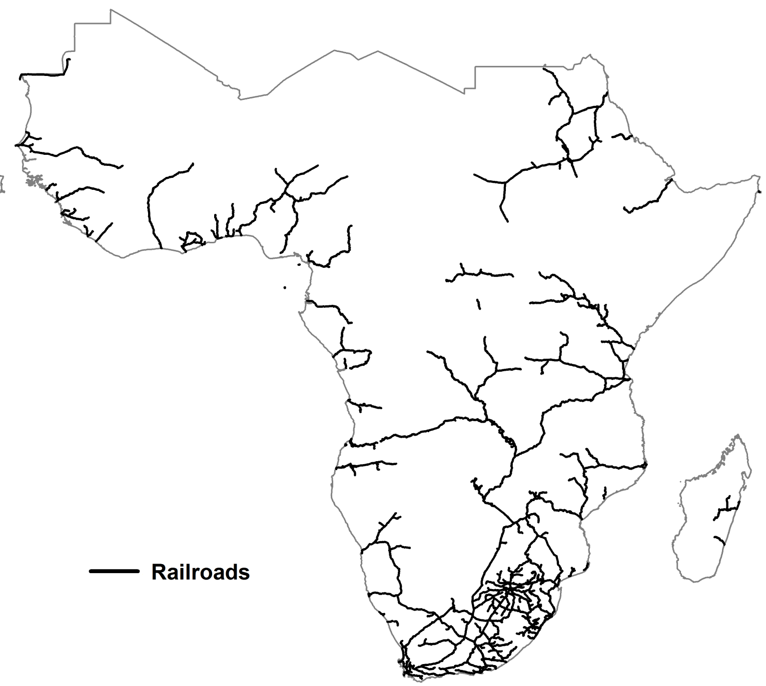
Wrigley, C. C. (1986) "Aspects of economic history," in A. D. Roberts ed. *The Cambridge History of Africa*, Vol. 7: Cambridge University Press, pp. 77–139.

Figure 1: Maps of the Road and Railroad Networks for the 43 sub-Saharan African Countries, Circa 2015

(a) Roads Circa 2015

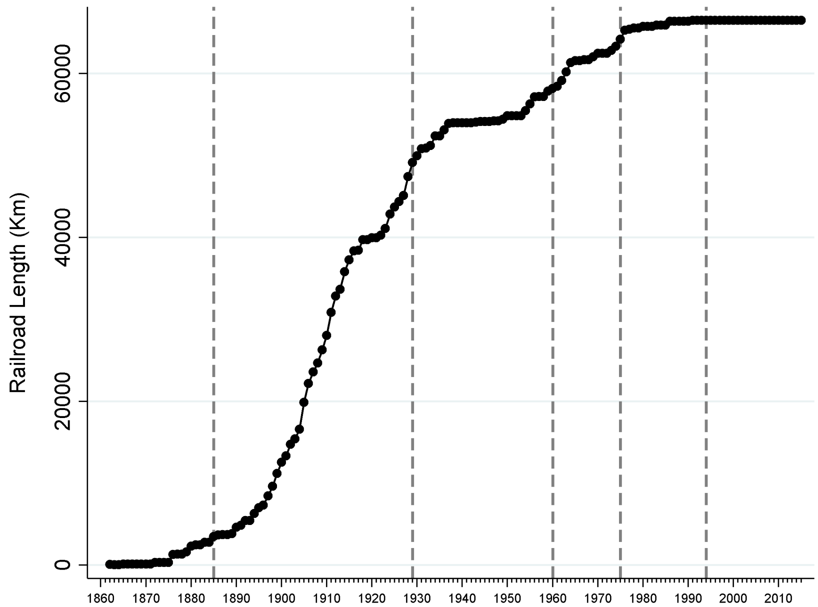


(b) Railroads Circa 2015



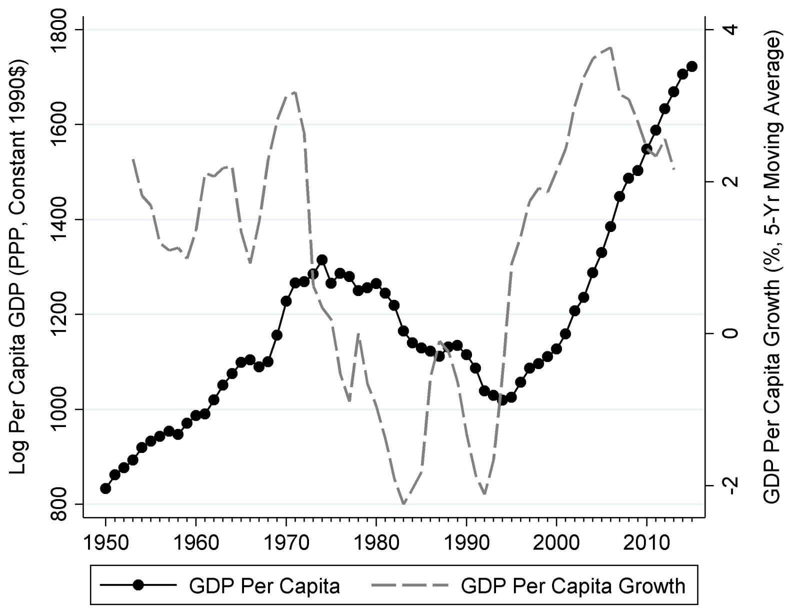
Notes: Subfigures 1a and 1b show the road network and the railroad network for the 43 sub-Saharan African countries of our main sample circa 2015. More precisely, the roads are for the year 2014 for 18 countries and the year 2012 for 25 countries, and the railroads are for the year 2015. Roads are classified into four categories: *highways, paved roads, improved roads* (e.g., gravel or laterite roads), and *dirt roads*.

Figure 2: Evolution of the Railroad Network for the 43 Sample Countries, 1862-2015



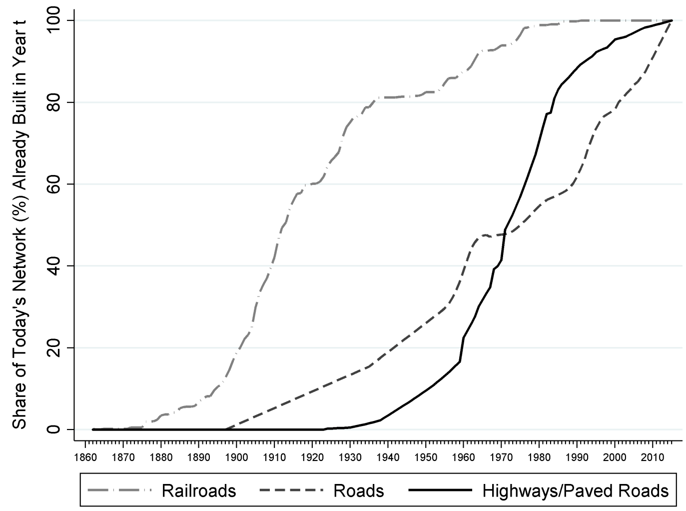
Notes: This figure shows the aggregate evolution of the railroad network for the 43 sub-Saharan African countries of our main sample between 1862 and 2015. 1862: Opening of the first railway in sub-Saharan Africa, the Cape Town-Wellington Railway in South Africa. 1885: Berlin Conference. 1929: Great Depression. 1960: Median independence year. 1975 & 1994: First and last year of the economic recession in our sample of 43 sub-Saharan African countries respectively (see figure 3).

Figure 3: Evolution of GDP Per Capita for the 43 Sample Countries, 1950-2015



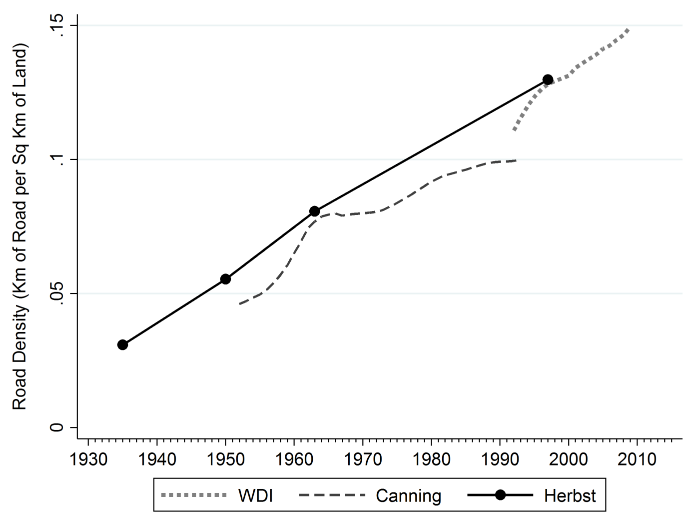
Notes: This figure plots GDP per capita and GDP per capita growth (%) for the group of 43 sub-Saharan African countries of our main sample (population weighted averages) between 1950 and 2015. Per capita GDP (in constant 1990 international Geary-Khamis dollars) comes from the *Maddison project database* compiled by Bolt and van Zanden (2014). As the Maddison database only has per capita GDP until 2010, we use the per capita growth rates (in purchasing power party terms and in constant international dollars) available in the *World Development Indicators* database (World Bank, 2016b) to reconstruct per capita GDP for the period 2011-2015. We use a 5-year moving average (i.e. +/- 2 years) to reduce the year-to-year volatility in GDP per capita growth. The population of each country in each year comes from the *World Population Prospects* database of the United Nations (2015a).

Figure 4: Relative Evolutions of the Railroad and Road Networks, 1830-2015



Notes: This figure shows the percentage shares of the railroad network, total road network (incl. highways, and paved, improved and dirt roads) and paved road (incl. highways) that have already been built by year t for the 43 sub-Saharan African countries of our main sample between 1830 and 2015, using the data from Figures 2, 5 and 6a. The first car to be imported in sub-Saharan Africa was in 1897 in South Africa. Before that, the few existing roads could not be considered as modern roads. We thus assume that the total length of roads in the 43 countries was nil in 1897. Likewise, the tarmac technology was only invented in 1901, and the first road to be paved in sub-Saharan Africa was likely to be in Ghana in the year 1924. For 25 countries, we know the first year a road was paved. For this year, we assume that the length of paved roads is 1 km, and we then interpolate the data between this year and 1960. For the other 43 - 25 = 18 countries, we assume that the length of paved roads is 0 before 1960, and 1 in 1960, and we then interpolate the data between 1960 and the first year a road was paved post-1960.

Figure 5: Evolution of Total Road Density for the 43 Sample Countries, 1935-2011

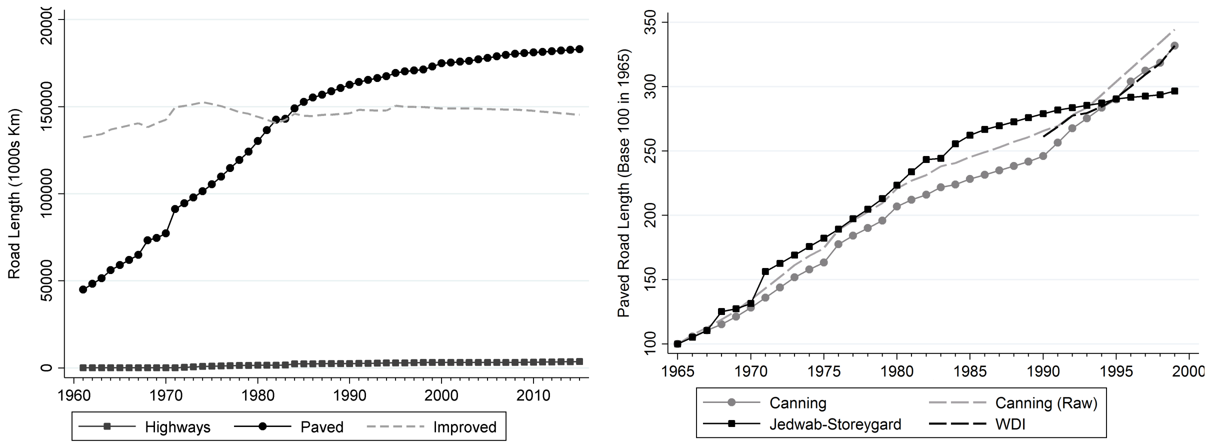


Notes: This figure shows the aggregate evolution of road density (km of any type of road per sq km of land) for the 43 sub-Saharan African countries of our main sample between 1935 and 2011. Population-weighted average road density in 1935, 1950, 1963 and 1997 comes from Herbst (2000) and is available for 33, 27, 38 and 38 sub-Saharan African countries only. Canning (1998) ("Canning") and the *World Development Indicators* ("WDI") database have data on total road length for selected country-year observations in 1950-1995 (1,050 obs. out of 41 countries $\times$ 46 years = 1,886 potential obs.) and 1990-2011 (509 obs. out of 43 countries $\times$ 22 years = 946 potential obs.) respectively. We first interpolate and extrapolate their data to fill the missing gaps in each period. Knowing the land area of each country, we then estimate their total road density in each year. We next obtain the population-weighted average of road density for the full sample in each year. Lastly, we report a five-year moving average (i.e. +/- 2 years) of both Canning and WDI. The population of each country in each year comes from the *World Population Prospects* database of the United Nations (2015a).

Figure 6: Evolution of the Road Network for 39 Sample Countries, 1960-2015

(a) Total Length of Each Road Type

(b) Total Length of Paved Roads

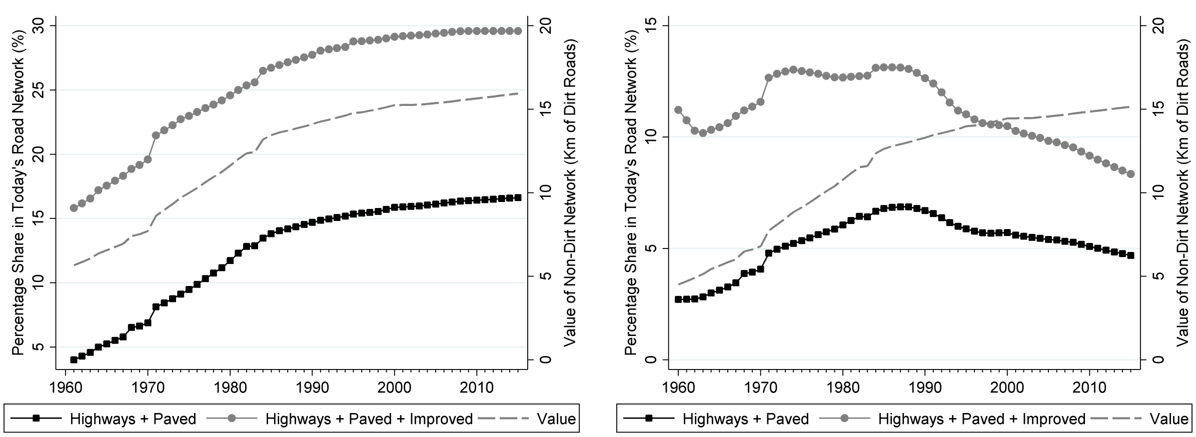


Notes: Subfigure 6a shows the length (000s km) of each road type for the 43 sub-Saharan African countries of our main sample between 1960 and 2015: *highways*, *paved roads* and *improved roads*. Subfigure 6b shows the total length of highway/paved roads (base 100 in 1965) in our data set, in the full database of Canning and Farahani (2007) for which he also uses WDI data (World Bank, 2006) and in the restricted database ("Raw") of Canning (1998) for which he does not use such data. We restrict the comparison to the 1965-1999 period, because the Canning (1998) database has fewer than 15 observations a year in other years. We also drop 4 countries for which the Canning (1998) database has fewer than 10 years of data (the DRC, Eritrea, Somalia and Sudan). Lastly, we correct 7 problematic observations in Canning (1998), because they show improbably large increases or decreases in the paved road network: Nigeria 1994–1996, South Africa 1995 and Tanzania 1990–1992. We then interpolate and extrapolate the cleaned Canning (1998) database to fill the missing gaps during the whole period. Lastly, we obtain the total length of paved roads for the resulting sample of 39 countries in each year during the 1965-1999 period. Since the Canning (1998) database also includes intra-city roads whereas our database captures inter-city roads, the levels are not as comparable as the trends, and we use 1965 as a base year for both our series and his series. World Bank (2006) is normalized to the same base as Canning and Farahani (2007) in 1999.

Figure 7: Share of Paved Roads in the Road Network for 43 Sample Countries, 1960-2015

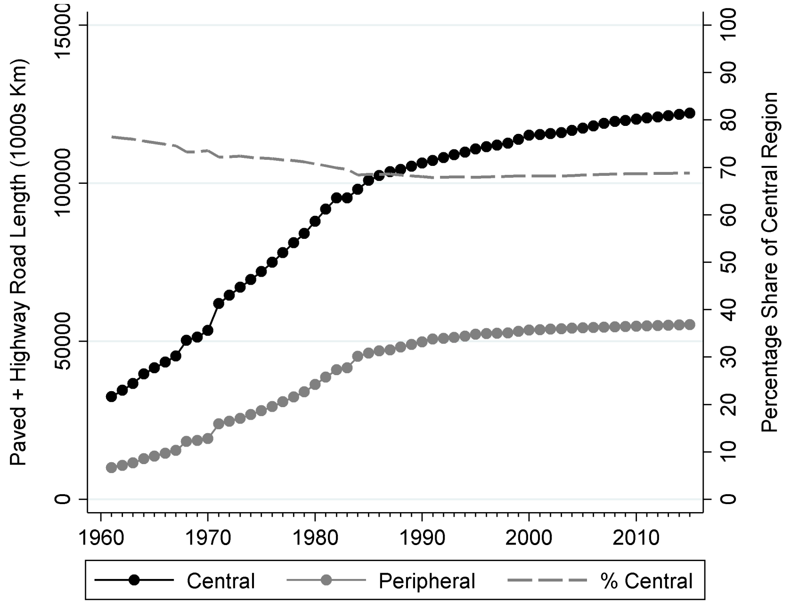
(a) Denominator: Nelson & Deichmann

(b) Denominator: Herbst & WDI



Notes: Subfigure 7.a shows the fraction (%) of paved roads broadly defined (incl. highways and paved roads strictly defined) and non-dirt roads (incl. highways, paved roads strictly defined, and improved roads) in the total road network defined circa 2004 from Nelson and Deichmann (2004), as well as the estimated total value of the road network expressed in km of dirt roads. We assume that a highway, a paved road and an improved road are 540, 60 and 15 times more "expensive" than a dirt road respectively. For each year t, the total road network value also includes the 2004 dirt roads that have not been upgraded by year t. Subfigure 7.b shows the fractions and the total value when using the total road network obtained from interpolating and extrapolating the road density data from Herbst (2000) and World Bank (2015a).

Figure 8: Evolution of Paved Road Network in Central vs. Peripheral Region



Notes: This figure shows total paved road length (km) for the central regions and the peripheral regions separately, as well as the percentage share (%) of the central paved road network in the total paved road network, between 1960 and 2015. To define the central regions, we divide each country into grid cells of 0.1x0.1 degrees (11x11km) and obtain the minimum distance from the cell's centroid to selected cities in the same country: The national capital(s) in 1960 and 2010 and the two largest cities in 1960. We divide all cells into two regions: "Central" if the distance is below the national median and "Peripheral" otherwise. We then use the GIS road data from Subfigure 1a to estimate the total length of paved roads (km) for each country-region-year observation for the 1960-2015 period.

Table 1: Core Variables and Transportation Infrastructure

Dependent Variable:	Log Difference in ... Roads (km) between $t-5$ and t					
	Highway	Paved	Improved	Highway/Paved	Non-Dirt	Rail
	(1)	(2)	(3)	(4)	(5)	(6)
Log ... Roads (km) t-5	-0.06*	-0.52***	-0.15***	-0.52***	-0.18***	-0.11***
	[0.03]	[0.05]	[0.03]	[0.05]	[0.05]	[0.02]
Δ Log Per Capita GDP t	0.02	0.41*	-0.21**	0.41*	-0.01	-0.45
	[0.14]	[0.22]	[0.10]	[0.22]	[0.04]	[0.30]
Δ Log Population t	0.27	-0.25	-0.46	-0.26	-0.25	0.74
	[0.27]	[0.39]	[0.38]	[0.40]	[0.20]	[0.54]
Δ Log Urbanization t	-0.02	0.06	0.33	0.06	0.28**	0.95**
	[0.32]	[0.49]	[0.27]	[0.49]	[0.14]	[0.47]
Log Per Capita GDP t-5	0.10*	0.31***	0.03	0.31***	0.08***	0.05
	[0.05]	[0.09]	[0.04]	[0.09]	[0.03]	[0.08]
Log Population t-5	0.18***	0.36***	0.07**	0.36***	0.09***	-0.01
	[0.06]	[0.06]	[0.03]	[0.06]	[0.03]	[0.02]
Log Urbanization $t-5$	0.18***	0.21*	0.03	0.22*	0.05	0.05
	[0.06]	[0.11]	[0.05]	[0.11]	[0.04]	[0.08]
Log Surface Area	-0.06**	0.07	0.06**	0.07	0.06***	0.02
	[0.02]	[0.05]	[0.02]	[0.05]	[0.02]	[0.03]
Adjusted R-squared	0.612	0.285	0.078	0.612	0.147	0.080
F test	22.35	2.811	5.726	22.35	3.757	0.745

Notes: The sample consists of 43 countries $\times$ 11 periods = 473 observations. All regressions include 11 year fixed effects. Robust SEs clustered at the country level. * p<0.10, ** p<0.05, *** p<0.01.

Table 2: Specification Checks with Core Variables

Dependent Variable:	Log Difference in Highway/Paved Roads (km) between $t-5$ and t					
	(1)	(2)	(3)	(4)	(5)	(6)
Log Highway/Paved t-5	-0.52***	-0.33***	-0.52***	-0.54***	-0.52***	-0.68***
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.06]
Δ Log Per Capita GDP t	0.41*	0.34		0.35	0.34	0.18
	[0.22]	[0.23]		[0.24]	[0.25]	[0.26]
Δ Log Population t	-0.26	-0.21		-0.29	-0.28	-0.13
	[0.40]	[0.69]		[0.44]	[0.49]	[0.33]
Δ Log Urbanization t	0.06	-0.35		-0.02	0.11	0.81**
	[0.49]	[0.51]		[0.53]	[0.49]	[0.40]
Log Per Capita GDP t-5	0.31***		0.32***	0.26***	0.23***	0.15
	[0.09]		[0.10]	[0.08]	[0.08]	[0.19]
Log Population t-5	0.36***		0.36***	0.37***	0.35***	0.81*
	[0.06]		[0.06]	[0.05]	[0.06]	[0.40]
Log Urbanization $t-5$	0.22*		0.20*	0.31**	0.30**	1.15***
	[0.11]		[0.11]	[0.13]	[0.13]	[0.42]
Log Surface Area	0.07		0.07	0.09*	0.09*	-0.01
	[0.05]		[0.05]	[0.05]	[0.05]	[0.07]
Adjusted R-squared	0.612	0.470	0.610	0.621	0.616	0.696
F test	22.35	19.25	31.77	19.61	12567	
Region FE (N = 4)	N	N	N	Y	N	N
Region-Year FE (N = 44)	N	N	N	N	Y	N
Country FE (N = 43)	N	N	N	N	N	Y

Notes: The sample consists of 473 observations. All regressions include 11 year fixed effects. Robust SEs clustered at the country level. * p<0.10, ** p<0.05, *** p<0.01.

Table 3: Core Variables of Interest, Robustness Checks

Dependent Variable:	Log Difference in Highway/Paved Roads (km) between $t-5$ and t						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log Highway/Paved t-5	-0.52***	-0.52***	-0.52***	-0.50***	-0.51***	-0.55***	-0.52***
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
Δ Log Per Capita GDP t	0.41*	0.42*	0.41*	-0.01	0.44*	0.59**	0.40*
	[0.22]	[0.23]	[0.22]	[0.13]	[0.23]	[0.28]	[0.23]
Δ Log Population t	-0.26	-0.29	-0.25	-0.10	-0.22	-0.09	-0.19
	[0.40]	[0.40]	[0.40]	[0.35]	[0.36]	[0.46]	[0.40]
Δ Log Urbanization t	0.06	0.07	0.06	0.26	0.05	-0.07	0.07
	[0.49]	[0.49]	[0.49]	[0.44]	[0.49]	[0.57]	[0.49]
Log Per Capita GDP t-5	0.31***	0.31***	0.31***	0.31***	0.32***	0.41***	0.29***
	[0.09]	[0.09]	[0.09]	[0.10]	[0.10]	[0.14]	[0.10]
Log Population t-5	0.36***	0.36***	0.36***	0.33***	0.35***	0.42***	0.35***
	[0.06]	[0.06]	[0.06]	[0.08]	[0.07]	[0.07]	[0.06]
Log Urbanization $t-5$	0.22*	0.22*	0.22*	0.14	0.22*	0.22	0.21*
	[0.11]	[0.11]	[0.11]	[0.12]	[0.12]	[0.13]	[0.12]
Log Surface Area	0.07	0.07	0.07	0.10*	0.06	0.05	0.07
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.06]	[0.05]
Δ Log Primacy t				-0.18			
				[0.31]			
Log Primacy $t-5$				-0.02			
				[0.14]			
Adjusted R-squared	0.612	0.612	0.612	0.639	0.589	0.621	0.612
F test	22.35	22.93	22.21	15.23	16.19	22.92	23.39
Specification	Baseline	MA_3 (pcgdp)	Land Area	Primacy Rate	No Extrapolated	No 2000s & 2010s	No South Africa

Notes: The main sample consists of 473 observations. All regressions include year fixed effects. (2): We use a moving average of $^+/_-1$ years for per capita GDP. (3): We control for land area instead of surface area. (4): We add the change and initial level in urban primacy (N = 428). (5): We drop the observations for which road length was extrapolated (N = 425). (6): We drop the 2000s & 2010s (N = 344). (7): We drop South Africa (N = 462). Robust SEs clustered at the country level. * p<0.10, ** p<0.05, *** p<0.01.

Table 4: Physical Geography, Conditional on Core Variables

Dependent Variable:	Log Difference in Highway/Paved Roads (km) between $t-5$ and t									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log Distance to Coast	-0.05								0.04	0.26*
	[0.06]								[0.17]	[0.14]
Log % 100 km Coast		0.02							0.04	0.17**
		[0.03]							[0.09]	[0.08]
Landlocked Dummy			0.05						0.07	0.01
			[0.11]						[0.16]	[0.13]
Log Ruggedness Index				0.07					0.05	0.08
				[0.05]					[0.09]	[0.05]
Log Soil Fertility					0.07				0.09	0.15***
					[0.05]				[0.06]	[0.05]
Log Av. Precipitations						-0.11			-0.07	-0.08
						[0.07]			[0.13]	[0.14]
Log % Tropical Climate							-0.03*		-0.02	-0.01
							[0.02]		[0.04]	[0.04]
Log % Desert land								0.02	-0.01	-0.05
								[0.02]	[0.03]	[0.04]
Adjusted R-squared	0.612	0.612	0.612	0.615	0.613	0.615	0.617	0.613	0.616	0.567
F test	20.05	20.99	19.85	20.14	19.49	20.58	20.23	24.36	13.74	7.733
Core Variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	N

Notes: The sample consists of 473 observations. All regressions include year fixed effects. Core variables are those in Table 1; all except log surface area are dropped in column (10). Robust SEs clustered at the country level. * p<0.10, ** p<0.05, *** p<0.01.

Table 5: Pre-Colonial Institutions, Conditional on Core Variables

Dependent Variable:	Log Difference in Highway/Paved Roads (km) between $t-5$ and t						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log State Antiquity (ρ = 5%)	0.01					-0.01	-0.01
	[0.04]					[0.06]	[0.06]
Log Centralization		0.11***				0.08**	0.06*
		[0.03]				[0.04]	[0.03]
Log Urbanization ca. 1910			-0.06			-0.06	0.03
			[0.04]			[0.05]	[0.06]
Log Slave Exports				-0.01		0.00	0.05***
				[0.02]		[0.02]	[0.02]
Log Ethnic Fractionalization					-0.27**	-0.20*	-0.24***
					[0.11]	[0.10]	[0.07]
Adjusted R-squared	0.608	0.624	0.615	0.613	0.620	0.622	0.565
F test	18.73	30.97	19.63	20.35	26.39	21.55	12.49
Core Variables	Y	Y	Y	Y	Y	Y	N
Observations	407	462	473	473	473	396	396

Notes: All regressions include year fixed effects. Core variables are those in Table 1; all except log surface area are dropped in column (7). Robust SEs clustered at the country level. * p<0.10, ** p<0.05, *** p<0.01.

Table 6: Colonial Institutions, Conditional on Core Variables

Dependent Variable:	Log Difference in Highway/Paved Roads (km) between $t-5$ and t						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log Settler Mortality	0.02						
	[0.04]						
Log % European Descent		0.21***				0.22**	0.16***
		[0.08]				[0.08]	[0.04]
Former English Colony			0.12			0.09	0.27**
			[0.08]			[0.13]	[0.11]
Former French Colony			0.28***			0.10	0.02
			[0.10]			[0.15]	[0.12]
French Legal Origin				-0.10		-0.08	0.03
				[0.09]		[0.15]	[0.11]
Colony in t-5					0.15	0.05	-0.29
					[0.27]	[0.28]	[0.28]
Adjusted R-squared	0.738	0.633	0.188	0.613	0.613	0.632	0.573
F test	19.77	22.17	4.331	22.01	20.50	20.61	15.12
Core Variables	Y	Y	Y	Y	Y	Y	N
Observations	264	462	473	473	473	462	462

Notes: All regressions include year fixed effects. Core variables are those in Table 1; all except log surface area are dropped in column (7). Columns (6) and (7) exclude the log settler mortality control as it is only available for 264 observations. Robust SEs clustered at the country level. * p<0.10, ** p<0.05, *** p<0.01.

Table 7: Post-Colonial Institutions and Natural Resource Dependence, Conditional on Core Variables

Dependent Variable:	Log Difference in Highway/Paved Roads (km) between $t-5$ and t								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Δ Non-Autocratic t	0.12							0.06	0.08
	[0.09]							[0.09]	[0.11]
Non-Autocratic t-5	0.17							0.05	0.17
	[0.12]							[0.13]	[0.13]
Δ Democratic t		0.11						0.08	0.06
		[0.11]						[0.11]	[0.12]
Democratic t-5		0.24**						0.20*	0.10
		[0.11]						[0.11]	[0.10]
Av. Rule of Law Index			0.04					0.01	0.04
			[0.06]					[0.12]	[0.13]
Conflict Dummy [t-5;t]				-0.05				-0.02	-0.01
				[0.07]				[0.07]	[0.06]
Δ % Nat.Res. in Merch.X t					-0.13			-0.09	-0.11
					[0.08]			[0.11]	[0.14]
% Nat.Res. in Merch.X t-5					-0.04			0.00	0.01
					[0.10]			[0.11]	[0.12]
Δ % Min.Res. in Merch.X t						-0.07**		-0.06*	-0.07*
						[0.03]		[0.04]	[0.04]
% Min.Res. in Merch.X t-5						-0.02		-0.01	0.02
						[0.03]		[0.03]	[0.03]
Δ % Agri. in Merch.X t							0.03	-0.00	-0.01
							[0.05]	[0.06]	[0.06]
% Agri. in Merch.X t-5							0.01	-0.01	0.00
							[0.04]	[0.04]	[0.04]
Δ Merchandise X in GDP t					-0.04	-0.02	-0.04	-0.03	-0.06
					[0.06]	[0.05]	[0.06]	[0.06]	[0.07]
% Merchandise X in GDP t-5					0.10*	0.10*	0.10	0.08	0.06
					[0.06]	[0.06]	[0.06]	[0.08]	[0.07]
Adjusted R-squared	0.613	0.616	0.612	0.612	0.616	0.619	0.616	0.615	0.553
F test	22.73	22.05	20.07	20.04	15.73	22.99	15.81	23.39	21.55
Core Variables	Y	Y	Y	Y	Y	Y	Y	Y	N
Observations	473	473	473	473	458	460	458	458	458

Notes: All regressions include year fixed effects. Core variables are those in Table 1; all except log surface area are dropped in column (9). Robust SEs clustered at the country level. * p<0.10, ** p<0.05, *** p<0.01.

Table 8: Resource-Based GDP vs. Non-Resource-Based GDP

Dependent Variable:	Log Difference in Highway/Paved Roads (km) between $t-5$ and t			
	(1)	(2)	(3)	(4)
Δ Log Per Capita GDP t: Non-Nat.Res.X	0.29			0.34*
	[0.19]			[0.19]
Log Per Capita GDP t-5: Non-Nat.Res.X	0.21**			0.21*
	[0.10]			[0.11]
Δ Log Per Capita GDP t: Nat.Res.X	0.01			
	[0.06]			
Log Per Capita GDP t-5: Nat.Res.X	0.11***			
	[0.03]			
Δ Log Per Capita GDP t: Non-Min.Res.X		0.37*		
		[0.20]		
Log Per Capita GDP t-5: Non-Min.Res.X		0.29***		
		[0.09]		
Δ Log Per Capita GDP t: Min.Res.X		-0.04**		-0.04**
		[0.02]		[0.02]
Log Per Capita GDP t-5: Min.Res.X		0.02		0.02
		[0.02]		[0.02]
Δ Log Per Capita GDP t: Non-Agri.X			0.40*	
			[0.21]	
Log Per Capita GDP t-5: Non-Agri.X			0.23*	
			[0.12]	
Δ Log Per Capita GDP t: Agri.X			0.00	0.02
			[0.05]	[0.05]
Log Per Capita GDP t-5: Agri.X			0.05	0.04
			[0.04]	[0.05]
Adjusted R-squared	0.617	0.614	0.610	0.610
F test	16.33	18.93	19.25	17.33
Core Variables Except GDP Variables	Y	Y	Y	Y
Observations	458	460	458	458

Notes: All regressions include year fixed effects and the Table 1 core variables except GDP. The "X" variables are the per capita GDP attributable to the corresponding export category. Robust SEs clustered at the country level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Table 9: Selected Variables Conditional on Core Variables

Dependent Variable:	Log Difference in Highway/Paved Roads (km) between $t-5$ and t							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Centralization	0.11***					0.07**	0.08***	0.07**
	[0.03]					[0.03]	[0.03]	[0.03]
Log Ethnic Fractionalization		-0.27**				-0.12	-0.19	-0.17
		[0.11]				[0.10]	[0.12]	[0.10]
Log % European Descent			0.21***			0.25***	0.28***	0.30***
			[0.08]			[0.07]	[0.08]	[0.07]
Δ Democratic t				0.11		0.11	0.09	0.08
				[0.11]		[0.09]	[0.08]	[0.08]
Democratic t-5				0.24**		0.22*	0.20	0.14
				[0.11]		[0.11]	[0.14]	[0.10]
Δ % Min.Res. in Merch.X t					-0.02	-0.01	0.00	0.01
					[0.03]	[0.03]	[0.03]	[0.03]
% Min.Res. in Merch.X t-5					-0.07**	-0.06**	-0.06*	-0.04
					[0.03]	[0.03]	[0.03]	[0.03]
Δ Merch.X in GDP t					0.10*	0.05	0.08	0.10
					[0.06]	[0.07]	[0.08]	[0.06]
% Merch. X in GDP t-5					-0.02	-0.04	-0.02	-0.03
					[0.05]	[0.05]	[0.06]	[0.06]
Adjusted R-squared	0.624	0.620	0.633	0.616	0.619	0.649	0.661	0.658
F test	30.97	26.39	22.17	22.05	22.99	35.78	45.93	
Region FE (N = 4)	N	N	N	N	N	N	Y	N
Region-Year FE (N = 44)	N	N	N	N	N	N	N	Y
Core Variables	Y	Y	Y	Y	Y	Y	Y	Y
Observations	462	473	462	473	460	438	438	438

Notes: All regressions include year fixed effects. Core variables are those in Table 1. Robust SEs clustered at the country level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Table 10: Central vs. Peripheral Regions: Core Variables of Interest

Dependent Variable:	Log Difference in ... Roads (km) between $t-5$ and t					
	Highway	Paved	Improved	Highway/Paved	Non-Dirt	Rail
	(1)	(2)	(3)	(4)	(5)	(6)
Log ... Roads (km) t-5	-0.05	-0.50***	-0.08***	-0.50***	-0.16***	-0.02
	[0.03]	[0.05]	[0.02]	[0.05]	[0.06]	[0.01]
Δ Log Per Capita GDP t	-0.06	0.63***	-0.20**	0.63***	-0.04	0.05
	[0.10]	[0.19]	[0.09]	[0.19]	[0.04]	[0.13]
Δ Log Population t	0.25	-0.59	-0.40	-0.59	-0.09	0.08
	[0.19]	[0.36]	[0.51]	[0.36]	[0.21]	[0.12]
Δ Log Urbanization t	0.04	0.02	0.10	0.02	0.10	0.53**
	[0.22]	[0.61]	[0.27]	[0.61]	[0.14]	[0.26]
Log Per Capita GDP t-5	0.09*	0.23***	-0.01	0.23***	0.06***	0.05
	[0.05]	[0.08]	[0.03]	[0.08]	[0.02]	[0.03]
Log Population t-5	0.11**	0.32***	0.04*	0.32***	0.08***	-0.00
	[0.04]	[0.06]	[0.02]	[0.06]	[0.03]	[0.02]
Log Urbanization $t-5$	0.08**	0.29**	0.06	0.29**	0.06*	0.01
	[0.03]	[0.11]	[0.04]	[0.11]	[0.03]	[0.02]
Log Surface Area	-0.03*	0.10**	0.04*	0.10**	0.06**	0.02
	[0.01]	[0.05]	[0.02]	[0.05]	[0.03]	[0.02]
Far Dummy	1.62**	0.94	-0.17	1.00	-0.42	0.07
	[0.76]	[1.60]	[0.44]	[1.60]	[0.64]	[0.25]
Far x Log Roads (km) t-5	0.03	0.31***	-0.00	0.31***	0.03	0.01
	[0.04]	[0.06]	[0.04]	[0.06]	[0.08]	[0.01]
Far x Δ Log Per Capita GDP t	0.10	-0.44	0.13	-0.44	-0.03	-0.11
	[0.09]	[0.27]	[0.12]	[0.27]	[0.09]	[0.10]
Far x Δ Log Population t	-0.36	2.19***	-0.63*	2.19***	-0.50	0.02
	[0.23]	[0.79]	[0.33]	[0.78]	[0.34]	[0.09]
Far x Δ Log Urbanization t	-0.08	0.98	0.58	0.98	0.70**	-0.21
	[0.18]	[0.83]	[0.36]	[0.83]	[0.30]	[0.25]
Far x Log Per Capita GDP t-5	-0.08	0.07	0.06	0.07	0.06	-0.01
	[0.05]	[0.13]	[0.05]	[0.13]	[0.05]	[0.02]
Far x Log Population t-5	-0.07**	-0.03	0.02	-0.03	0.03	0.01
	[0.03]	[0.08]	[0.02]	[0.08]	[0.04]	[0.01]
Far x Log Urbanization $t-5$	-0.03	-0.18*	-0.07*	-0.18*	-0.02	0.00
	[0.02]	[0.10]	[0.04]	[0.10]	[0.04]	[0.02]
Far x Log Surface Area	0.01	-0.25***	-0.03	-0.25***	-0.06	-0.02
	[0.01]	[0.05]	[0.03]	[0.05]	[0.04]	[0.02]
Adjusted R-squared	0.070	0.337	0.126	0.337	0.242	0.055
F test	14.29	23.38	8.856	23.42	2.637	0.687

Notes: The sample consists of 43 countries $\times$ 11 periods $\times$ 2 regions = 924 observations. All regressions include 11 year fixed effects. The *Far Dummy* is equal to one for peripheral regions, i.e. grid cells whose minimum distance to the national capital(s) of the same country in 1960 and 2010 and the two largest cities of the same country in 1960 is less than the median distance in the country. Robust SEs clustered at the country level. * p<0.10, ** p<0.05, *** p<0.01.

Table 11: Central vs. Peripheral Regions: Selected Other Variables

Dependent Variable:	Log Difference in Highway/Paved Roads (km) between $t-5$ and t							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Centralization	0.08***					0.04	0.04	0.03
	[0.03]					[0.02]	[0.02]	[0.03]
Far x Log Centralization	-0.03					0.04	0.04	0.04
	[0.05]					[0.05]	[0.05]	[0.05]
Log Ethnic Fractionalization		-0.26**				-0.16*	-0.17*	-0.14
		[0.10]				[0.09]	[0.10]	[0.09]
Far x Log Ethnic Frac.		0.20**				0.32**	0.32**	0.32**
		[0.10]				[0.12]	[0.13]	[0.13]
Log %European Descent			0.18**			0.21***	0.22***	0.24***
			[0.07]			[0.07]	[0.08]	[0.07]
Far x Log %Euro. Descent			0.02			0.19**	0.20**	0.19**
			[0.08]			[0.09]	[0.09]	[0.08]
ΔDemocratic t				0.15		0.15	0.12	0.12
				[0.12]		[0.11]	[0.11]	[0.12]
Far x ΔDemocratic t				-0.33*		-0.34*	-0.33*	-0.34*
				[0.18]		[0.19]	[0.19]	[0.20]
Democratic t-5				0.27***		0.25**	0.20*	0.14
				[0.10]		[0.11]	[0.12]	[0.10]
Far x Democratic t-5				-0.20*		-0.15	-0.15	-0.15
				[0.11]		[0.13]	[0.13]	[0.13]
Δ %Min.Res. in Merch.X t					-0.03	-0.02	-0.02	-0.01
					[0.03]	[0.03]	[0.03]	[0.03]
Far x Δ%Min.Res. in Merch.X t					0.04	0.05	0.05	0.05
					[0.03]	[0.04]	[0.04]	[0.04]
%Min.Res. in Merch.X t-5					-0.08**	-0.08**	-0.07**	-0.05
					[0.03]	[0.03]	[0.03]	[0.04]
Far x %Min.Res. in Merch.X t-5					0.09	0.08	0.08	0.08
					[0.08]	[0.08]	[0.08]	[0.08]
ΔMerch.X in GDP t					-0.03	-0.05	-0.04	-0.04
					[0.07]	[0.07]	[0.07]	[0.07]
Far x ΔMerch.X in GDP t					-0.09	0.00	0.01	0.01
					[0.12]	[0.12]	[0.12]	[0.12]
%Merch.X in GDP t-5					0.10*	0.04	0.06	0.08
					[0.06]	[0.07]	[0.07]	[0.05]
Far x %Merch.X in GDP t-5					-0.03	-0.01	-0.02	-0.01
					[0.09]	[0.12]	[0.12]	[0.12]
Adjusted R-squared	0.339	0.339	0.350	0.339	0.342	0.363	0.366	0.379
F test	26.86	33.61	22.86	21.93	29.67	476.6	712.6	
Region FE (N = 4)	N	N	N	N	N	N	Y	N
Region-Year FE (N = 44)	N	N	N	N	N	N	N	Y
Core Variables, Far, Core*Far	Y	Y	Y	Y	Y	Y	Y	Y
Observations	902	924	902	924	898	854	854	854

Notes: All regressions include year fixed effects, the core variables, the far dummy, and the interactions of the far dummy with each core variable, as in Table 10. Robust SEs clustered at the country level. * p<0.10, ** p<0.05, *** p<0.01.